Memoirs of the Museum of Comparative Zoölogy
AT HARVARD COLLEGE.
Vol. XLVI. No. 1.

HAWAIIAN AND OTHER PACIFIC ECHINI.

THE CLYPEASTRIDAE, ARACHNOIDIDAE, LAGANIDAE, FIBULARIIDAE, AND SCUTELLIDAE.

BY
HUBERT LYMAN CLARK.

WITH TWENTY-TWO PLATES.

Plates 122–143.

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CAMBRIDGE, U.S.A.:
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HAWAIIAN AND OTHER PACIFIC ECHINI.

Collected by the U. S. Fish Commission Steamer Albatross, Commander Chauncey Thomas, U. S. N., Commanding in 1902, and Lieut. Commander L. M. Garrett, U. S. N., Commanding in 1906.

CLYPEASTRINA Gregory.

General Characteristics.

Although closely related to the now extinct Holectypina, the suborder Clypeastrina is sharply marked off from all recent Echini by the form of the test, the position of the periproct, the presence of jaws and auricles, in the absence of peristomal gills, and the usually petaloid arrangement of the ambulacra aborally. Such a combination of characters gives them a general appearance which is usually easily recognizable and as they all resemble more or less closely the well-known species of the typical genus Clypeaster, they have come to be colloquially known as clypeastroids. The group is not only well defined and homogeneous but is a relatively small one and of comparatively recent geological appearance.

There is good ground for the belief that they arose in connection with the Holectypina from a stirodont group of regular Echini, of which the Arbaciidae are modern representatives. The evidence in support of this belief has been briefly set forth by Jackson (1912, Phylogeny of the Echini. Mem. Boston Soc. Nat. Hist., 7, p. 217). But it ought to be pointed out that the primary tubercles in *all* clypeastroids are *perforate*, while this is true of no Stirodonta save some of the fossil Saleniidae. This may be interpreted however, simply as the retention of an ancestral character, for it is found in all the primitive regular Echini.

The classification of the clypeastroids is based primarily upon the auricles, with which the well developed but characteristic lantern is associated. In the more typical and primitive members of the group, the auricles of each ambulacrum are not only distinct but are well separated from each other. In more specialized forms the right hand auricle of one ambulacrum and the left hand auricle of the adjoining ambulacrum have become more or less completely transposed on to the separating interambulacral plate and are more or less fused into a

single upright piece. This remarkable migration of the auricles is one of the most notable features of clypeastroid morphology, and divides the suborder into two distinct groups.

Another character of some importance is to be seen at the other end of the interambulacra. Here, where the interambulacrum adjoins the genital plate, there are usually two small plates to be seen side by side, terminating the two columns of interambulacral plates, as in regular Echini. But in some clypeastroids, one of this pair greatly outstrips the other in growth and comes ultimately to occupy the entire aboral end of the interambulacrum, increasing in size most disproportionately as the test grows. In other clypeastroids, the oral end of the interambulacrum may undergo a curious change during growth, by which the primordial interambulacral plate remains in the basicoronal row, but is separated from its fellows by the crowding in of ambulacral plates, making what is called a "discontinuous interambulacrum."

The shape of the test, the position of the anus, the number and position of the genital and madreporic pores, and the character of the buccal membrane are all characters of more or less importance. Probably the form of the test is very directly connected with the manner of life for it is known that the very flat, discoidal species live a strictly subarenaceous life while the higher, more "biscuit-shaped" species live *on* the bottom where they are only in part or not at all covered by sand. It must be admitted that we know almost nothing from actual observations as to the habits of these Echini, and possibly some assumptions as to the significance of certain test-forms are quite erroneous. Accompanying the flattening of the test, there has been a marked development of internal calcareous supports in the form of pillars, walls and horizontal floors. In some cases, as Echinocyanus, these appear early in development and undergo little change with age and are hence of systematic importance, but as a rule the deposit of this extra calcareous matter goes on for a long time, perhaps throughout life, and with varying rates in different individuals. The resulting features of internal structure are therefore very diversified and I have been unable to make any satisfactory use of these characters for systematic purposes, except in the Fibulariidae.

The occurrence of *lunules* or slits extending through the entire test, permitting the free passage of water between the oral and aboral surfaces, is a remarkable feature of many of the discoidal clypeastroids. The lunules may be either ambulacral or interambulacral in position but always lie with the long axis parallel to the radius of the test. They arise in the course of development, either as notches in the test margin which become deeper with the growth of the

test and ultimately are closed in at the distal end, or as depressions on the oral side of the test which by resorption ultimately perforate both the oral and aboral plates and attain to the full size of the lunule. But whether the two processes have developed simultaneously in phylogeny or whether one is more primitive than the other, is still unsettled. There are some reasons, however, for believing that the resorptive process was the first to occur and that the lunule of the posterior interambulacrum is the oldest phylogenetically. Practically nothing is known as yet as to the function of the lunules — granting that they have any. In certain genera, notably Rotula, marginal slits, which never close to form lunules, occur, particularly in the posterior interambulacrum and the adjoining ambulacra. Their use is as obscure as that of the lunules.

Another remarkable feature of the clypeastroids is the extension of the ambulacral tube-feet on to other portions of the test than the strictly "poriferous areas" of the ambulacra. The modification of the aboral part of the ambulacra to form the characteristic "petals" is so well known, no description of it is necessary here, though the form of the petals and certain details of their structure are of great systematic importance. But the occurrence of a multitude of very minute ambulacral feet is not so generally known. Mr. Agassiz (1874, Rev. Ech., pt. 4, p. 695) has described the distribution of these supernumerary pedicels in several genera, and Miss Gregory (1911, Zool. Anz., **38**, p. 323) has given a detailed account of them, as seen from the interior of the test, in Echinarachnius. There is, however, much still to be learned in regard to their distribution in the different genera. The resemblance between the distribution of the pedicels in Echinarachnius and in such holothurians, as Thyone, is a most striking example of "parallelism," the genetic connection between the two groups being of course very indirect. Associated with this multiplication of pedicels in the clypeastroids is the development of what are called the "ambulacral furrows," grooves on the outer surface of the oral side of the test, radiating out from the mouth and extending in the median ambulacral area towards the margin. They may be simple, short and indistinct, or simple (*i. e.* unbranched) and extending clearly to the margin, or branched more or less extensively and some or most of the branches reaching the margin. Their arrangement is a feature of some systematic importance.

The anus, or better the periproct, lies near the margin of the test in the posterior interradius. In young individuals it is more or less aboral in position and in adult Arachnoides, it is more aboral than oral. In several cases it is marginal, but most commonly it is distinctly on the oral surface. In extreme

cases, in the Scutellidae, it is not far from the mouth and in many genera its distance from the margin is an important specific character. Usually the periproctal plates carry miliary spines and sometimes pedicellariae, but in some species they are quite naked.

The genital pores vary in number, size, and position. In Clypeaster and some other genera, there are typically five pores and any other number is very rare even as an individual variant. These five pores are in the interradii at, or very near, the margin of the fused oculogenito-madreporic body. In the Laganidae, the number of pores may be either four, five, or six and they may lie far down in the interradii instead of near the abactinal system. When six pores are present, there are two in the posterior interradius. In the other families the number of pores is commonly four but five is characteristic of some genera. The number and position of the ocular pores shows so little diversity that they are of no use for systematic purposes. There are always five and they lie close to the margin of the oculogenito-madreporic body.

The madreporic pores are usually numerous and occupy most of the surface of the plate formed by the fusion of the oculars and genitals; for this reason I have called this plate the oculogenito-madreporic body. In the recent Fibulariidae there is only a single madreporic pore and it is conspicuously large. This is a useful systematic character and is of great help in distinguishing these little clypeastroids from young Clypeasters, for the latter have at least several madreporic pores even when only a few millimeters long. It should be noted however that *Fibularia nigeriae* Hawkins, a Tertiary species, is said to have numerous madreporic pores.

In addition to the tubercles which bear spines and pedicellariae, the tests of many clypeastroids bear low rounded elevations, known as "glassy tubercles." These take their name from the fact that they are composed of an unusually dense carbonate of lime, which is clear and transparent and thus, when cleaned from the overlying epidermis, resembles glass. The function of these tubercles is not known and their use for systematic purposes is very slight.

The buccal membrane in clypeastroids is generally thin and lacks calcareous matter but Arachnoides is exceptional in that there are distinct plates on the membrane, which carry miliary spines. The same seems to be true of Rotula, though the available material of this genus is too poor for a satisfactory determination of the point.

The Spines, Pedicellariae, Sphaeridia, and Spicules.

Plates 122–125.[1]

In all clypeastroids the test is densely covered with spines. Occasionally one can distinguish *three* very distinct sizes of spines, which might be called primaries, secondaries, and miliaries, but since these so-called primaries are present in very few species and are not surrounded by circles of secondaries, it has become a general custom to speak of the spines of clypeastroids as "primaries" and "miliaries" only, the term "secondary" not being used. We therefore speak of the conspicuous spines in such species as *Clypeaster lamprus* as "large primaries." Occasionally one finds the term "secondary" but it is used simply as a synonym of miliary; thus de Meijere, in his notable account of the clypeastroids of the Siboga (1904, Siboga Echini, p. 103–139) occasionally refers to "secundärstacheln" but in every case the context shows that he means miliaries. It was due to his careful work that attention was first called to the characteristics of the miliary spines in the Laganidae and the striking difference there is between them and those of the Clypeastridae. Apparently de Meijere has gone too far in attempting to find specific and generic characters in the miliary spines, for examination of these spines from nearly all the known species of Laganidae has satisfied me that there is so much individual diversity and so much evidence of varying degrees of wear on the tips of these spines, that they are of little real value for specific distinctions. But the fact remains that the form and structure of the terminal portion of both primary and miliary spines in clypeastroids are characters of real importance in working out the interrelationships of the genera.

In all the genera, the primary spines are solid, but they may be either straight (Pl. 122, figs. *9*, *11*, *16*, *17*), curved (Pl. 122, figs. *12*, *14*) or bent (Pl. 125, fig. *16*); they may taper to a sharp point (Pl. 122, fig. *9*) or be quite blunt (Pl. 122, fig. *16*), or be flattened and chisel-like (Pl. 122, figs. *12*, *13*), or simply expanded (Pl. 122, fig. *1*) or be much swollen at the tip (Pl. 125, figs. *4*, *5*, *17*, *18*); they may be quite smooth (Pl. 122, fig. *16*) or serrated along one side (Pl. 122, fig. *14*) or more or less rough with serrations on all sides (Pl. 125, figs. *4*, *5*); they are commonly longitudinally striated, the striations being raised as more or less evident ridges, which may be quite serrate; there is sometimes a marked difference between base and tip of spine in the smoothness or roughness of its surface.

[1] The numeration of the plates is continuous throughout the reports on the Hawaiian and other Pacific Echini (Memoirs M. C. Z., **34**).

None of these varying peculiarities of the primary spines are distinctive of particular groups but examination of the miliary spines shows two distinct types of structure, one of which occurs only in two families, the other only in the remaining three. In the Fibulariidae and Laganidae, the miliary spines have the appearance of groups of flattened rods, more or less expanded at their tips, and bound together by horizontal bars placed rather near together. At the base, these spines seem fairly solid but distally they have an open, lattice-like appearance. Attention was first called to the characteristic structure of these small spines by de Meijere (1904, *loc. cit.*), who showed how the flattened rods differed in different species. They are sometimes gradually (Pl. 124, fig. *14*), sometimes abruptly (Pl. 124, fig. *18*) expanded at the tip, and the terminal margin may be smooth or finely or coarsely serrate. The spine as a whole is commonly somewhat expanded at tip, *i. e.* the rods are more or less flaring. Often the rods are not all of equal length but those of one side may be much shorter than the others; in such a case the tip of the spine is more or less oblique. Examination of much material has convinced me that the degree of obliqueness is subject to great variation due to the position of the spine on the test and the amount of wear it has received. The amount of serration on the rod-tips is also affected by the same factors, and smooth, finely serrate, and coarsely serrate rods occur in the same individual.

In the remaining families of Clypeastrina, the miliary spines are solid like the primaries but the longitudinal ridges are dentate and their chisel-like teeth are more or less finely serrate (Pl. 122, figs. *7*, *8*, *10*). Such miliary spines may be cylindrical (Pl. 122, fig. *7*) or more or less swollen at the tip (figs. *8*, *10*). They do not show signs of wear as evidently as do the miliaries of the Laganidae. They show little diversity in form or structure and are of little use for systematic purposes.

One of the most interesting facts brought out by a study of the pedicellariae of the clypeastroids is that these organs reveal a steadily decreasing importance as we pass from the older and more primitive forms to those which are more highly specialized. In most species of Clypeaster pedicellariae of at least three kinds are more or less common, and may even be abundant. No globiferous pedicellariae are known in the genus, or in any of the Clypeastrina, but tridentate, ophicephalous, and triphyllous forms occur on both oral and aboral surfaces. As a rule, the ophicephalous pedicellariae are chiefly aboral and the tridentate chiefly oral, while the triphyllous may occur on either surface with equal frequency. In some species, large pedicellariae, like the tridentate, occur

with four valves and these *quadridentate* pedicellariae might perhaps be considered the most specialized form occurring in the suborder. In the Laganidae also, pedicellariae of three kinds occur and in some species are quite common and the same seems to be true of the Fibulariidae, so far as known. In Arachnoides, pedicellariae are excessively rare, some fine specimens seeming to lack them altogether. Those that do occur are all of one kind, small and with only two valves. In the Scutellidae, we find a similar marked reduction in the number and size of the pedicellariae. Only in one species of Echinodiscus have I found ophicephalous pedicellariae, and in no other genus of the family. The tridentate and triphyllous pedicellariae are very small, and commonly have but *two* valves. The triphyllous are so small, it is only by the greatest care that they can be found. The tridentate, or more properly the bidentate, in *Echinarachnius parma* show the further degradational feature of a total lack of apophyses in the valves. Taking all the facts into consideration it seems clear that the clypeastroids have sprung from a stock, provided with ophicephalous, tridentate, and triphyllous pedicellariae and it may be added that to no family of regular Echini do they show a closer resemblance in these particulars than to the Saleniidae. Adaptation to a more or less subarenaceous life seems to have been the cause of a degradational change in the pedicellariae so that as the test has become more and more flat and discoidal, there has been first a loss of the ophicephalous pedicellariae, and a reduction in number of all kinds, and this has been followed by a reduction in the size and number of valves of the pedicellariae themselves, until the condition is reached which is characteristic of Arachnoides, where the pedicellariae are very scarce, all of one kind, very small and with only two valves. Further reduction to complete extermination seems to occur in some individuals of this genus.

The *ophicephalous* pedicellariae of clypeastroids, when present at all, always have three valves (Pl. 123, fig. *17*), of which one has a very large basal "loop," the second has a moderate one and the third has little or none (Pl. 123, figs. *5*, *6;* Pl. 124, figs. *10–12*). The shape of the loop shows great diversity but is of little importance as a specific character. The blade (Pl. 123, fig. *4;* Pl. 124, figs. *9*, *21*) is equally variable in form but is of more taxonomic importance. The stalk of these pedicellariae is longer than the head but is solid and rather stout, and is hollowed at the top (Pl. 124, fig. *13*) so that the loops actually set into the cavity. The heads are always small, .10–.20 mm. long with the loops adding about half as much again.

The *bidentate, tridentate,* and *quadridentate* pedicellariae are the commonest

forms, occurring in all the genera examined, although they are often very "few and far between." In them all, the stalk usually about equals the head, though it may be either longer or shorter, and the neck is relatively quite short. They differ from each other chiefly, as the names used indicate, in the number of valves. The *quadridentate* (Pl. 123, figs. *10*, *11*) are the least common, having been found only in certain species of Clypeaster. They are the largest pedicellariae of the suborder, the valves sometimes exceeding a millimeter in length. The valves are compressed and meet only at the tip. The *tridentate* (Pl. 123, figs. *1*, *29*, Pl. 124, fig. *1*) are also often of large size, with valves exceeding a millimeter in length, but they may be very small, not one tenth the size of the large ones. They are found in all species of Clypeaster, and in the Laganidae, Fibulariidae, and some Scutellidae. The valves meet at or near the tip or for more or less of their entire length; they are sometimes straight but more commonly are curved to a greater or less degree. These pedicellariae show great diversity not only in size and relative abundance, but in the form of the valves. The latter occasionally have "loops" as in ophicephalous pedicellariae, but the shape of the blade never approaches the characteristic ophicephalous form. With the triphyllous pedicellariae however, the tridentate show an evident intergradation and the line between the two kinds is purely arbitrary. The *bidentate* pedicellariae (Pl. 125, figs. *2*, *23*) occur only in the Arachnoididae and Scutellidae. They do not occur with either quadridentate or tridentate. They are always small, the valves never exceeding .50 mm. and being usually less than .30. The two valves meet only at or near the tips and are usually distinctly compressed. They are of very diverse shapes and those of Echinarachnius are remarkable for the absence of any apophysis, so that no distinction between base and blade is feasible.

The *biphyllous* and *triphyllous* pedicellariae differ from the bidentate and tridentate chiefly in being smaller and in having the valves of more bizarre shape and in usually having a very much longer stalk and longer neck. They differ from each other only in the number of valves. The *biphyllous* (Pl. 125, fig. *7*) have the valves usually somewhat compressed but meeting broadly at the tip; they are only .05–.10 mm. in length. They are found only in the more specialized Scutellidae. The *triphyllous*, on the other hand, occur in the less specialized Scutellidae and in all the other families except the Arachnoididae. The valves are no larger than those of the biphyllous and because of their very small size they are often exceedingly hard to find. The blade is generally somewhat expanded and its margin may be finely serrate (Pl. 123; figs. *24*, *25*) or dentate (Pl. 124, figs. *20*, *23*).

Although *sphaeridia* occur in all known genera of Clypeastrina, their small size and more or less complete concealment within the calcareous matter of the test itself makes them of little use for systematic purposes. It may be mentioned in passing that the presence of depressions or even deep cavities within which the sphaeridia occur is characteristic of the Arbaciidae alone among the families of regular Echini.

The *calcareous particles* in the tube-feet of the clypeastroids show the same gradual decrease in size and importance that the pedicellariae reveal. This is very probably associated with the change of function of the pedicels from locomotor to respiratory. In the less specialized genera, there is a well-developed calcareous plate in the disk of each pedicel; this plate is perforated by a large central opening and many small ones nearer the margin; it is more or less well provided with projections on the outer margin. Besides this plate a few calcareous rods may be present in the wall of the foot but they are insignificant and commonly wanting. In the Laganidae the terminal plate is less well developed than in Clypeaster and in most cases seems to be wanting as it is also in the Fibulariidae. In the Arachnoididae, it is reduced to a very slender ring surrounding the tip of the pedicel. In the Scutellidae, it is entirely wanting but in several genera is replaced by two rods, lying side by side at the center of the disk; these rods are somewhat bent or curved, so that they are further apart at the middle than at either end, and on the outer side is a projecting tooth or several knobs.

The Families of Clypeastrina.

In the Revision of the Echini, Mr. Agassiz (1873, Rev. Ech., pt. 3, p. 505, 524) recognizes two families of clypeastroids, the Euclypeastridae and the Scutellidae. In the former, he grouped the genera into three subfamilies, Fibularina, Echinanthidae, and Laganidae; Arachnoides he placed in the Scutellidae, expressing himself (p. 529) as strongly opposed to the removal of the genus from that family. Duncan (1889, Journ. Linn. Soc. Zool., 23, p. 143) adopts essentially the same classification but he raises each of the three subfamilies to full family rank, calls the Echinanthinae by the more correct name Clypeastridae and recognizes the peculiarities of Arachnoides by making it the only genus of a subfamily "Arachninae" under Scutellidae. He omits any subfamily name for the other genera of the family, but no doubt he intended to use "Scutellinae." Gregory (1900, Lankester's Treatise on Zoology, 3, p. 316) adopts the same four families but removes Arachnoides from the Scutellidae altogether and makes it a separate

subfamily of the Clypeastridae. MacBride (1906, Echinodermata, Cambridge Natural History, 1, p. 549) adopts the same four families but, without any explanation of such an inexcusable move, puts Arachnoides in the Laganidae! Evidently then, except for the genus Arachnoides, all writers are agreed on the primary subdivisions of the clypeastroids. As I consider the arrangement of the auricles of fundamental importance, I believe Gregory's classification is the most natural of those hitherto proposed, but, as I have already pointed out (1911, Ann. Mag. Nat. Hist., ser. 8, 7, p. 593–605), Arachnoides is so different from all Clypeastridae, I prefer to raise Gregory's subfamily Arachnoidinae to full family rank, and thus recognize five families of Clypeastrina.

There can be little question that the Clypeasteridae are the least specialized forms, the character of the auricles, the structure of the spines, and the pedicellariae all giving weight to this conclusion. From such a stock or a nearly related one, Arachnoides has developed, becoming very flat and discoidal, and losing its pedicellariae in connection with its subarenaceous life. The Laganidae and Fibulariidae show by their miliary spines and pedicellariae, as well as by the structure of the auricles and interambulacra, that they have come from a common stock, for I cannot believe that the simple features of the fibularine ambulacra are primitive. They seem to show a secondary simplicity. The Scutellidae are of course the most specialized forms, but which genus is to be considered the most extreme I am not prepared to say. Very likely it is Rotula but my material of that genus does not warrant an opinion.

Key to the Families of Clypeastrina.

Auricles separate, each placed more or less clearly on the ambulacrum.
- Test rarely discoidal, and usually not flat; anus marginal or inframarginal; genital pores 5. CLYPEASTRIDAE.
- Test very flat, discoidal; anus supramarginal; genital pores 4 . . . . . ARACHNOIDIDAE.

Auricles fused into a single piece situated on the interambulacrum.
- Test seldom discoidal and never with marginal slits or lunules; aboral end of each interambulacrum consists of a single large plate adjoining genital; ambulacral furrows on oral surface short and indistinct, or wanting.
  - Petals more or less perfect; madreporic pores numerous; size moderate to large (15–150 mm. in length) . . . . . LAGANIDAE.
  - Petals reduced and often rudimentary; only one madreporic pore; size small, rarely up to 15 mm. in length . . . . . FIBULARIIDAE.
- Test flat and usually discoidal, often with marginal slits or lunules; aboral end of each interambulacrum with the usual pair of small plates adjoining genital; ambulacral furrows distinct, at least the posterior reaching to the margin . . SCUTELLIDAE.

CLYPEASTRIDAE Agassiz.

This family includes the largest clypeastroids known and very few of the species are less than 75 mm. in length when fully grown. Although the arrangement of the auricles and the lantern-muscles (see Jackson, 1912, Mem. Boston Soc. Nat. Hist., 7, p. 196), the structure of the spines, and the number, variety and form of the pedicellariae all indicate that the family as a whole is the least specialized in the suborder, yet many of the species show by the completely formed petals, the very flat test, and the position of the anus a very considerable specialization. While the test is decidedly flattened in most of the species, there are some in which it is more or less highly arched and the generic position of these has been a source of considerable discussion. Among these, an Australian species, described in 1878 by Tenison-Woods under the name *Echinanthus tumidus*, is particularly interesting and there is no doubt Bell was quite right in making it the type of a new genus, Anomolanthus. Another of the high forms and one of the best known members of the family has long borne the name of *Echinanthus rosaceus* but under the International Code, the name Echinanthus may not be used for a clypeastroid (see H. L. Clark, 1911, Ann. Mag. Nat. Hist., ser. 8, 7, p. 594). Moreover *rosaceus* is undoubtedly the type of Lamarck's genus Clypeaster and consequently, if the highly arched and the flattened species of Clypeastridae are to be separated generically from each other, it is the former and not the latter which retain the name Clypeaster. But after a careful study of nearly all the recent species, I have concluded that the gradations in the form and structure of the test are so complete, it is better to let all the species of the family, recent, Quarternary, and Tertiary, except the Australian form referred to above as Anomolanthus, rest in the single genus Clypeaster. There is thus no occasion to use Duncan's proposed genera Plesianthus and Diplotheeanthus. Possibly a careful revision of the fossil forms may show some good generic groups among them but for the recent species, a single genus will answer.

Key to the Genera of Clypeastridae.[1]

Poriferous areas of petals divergent, not incurved distally; anus marginal . . . . . *Anomolanthus.*
Poriferous areas of petals more or less incurved distally; anus inframarginal . . . . *Clypeaster.*

[1] In this and all subsequent keys only recent forms are considered.

Anomolanthus.

Bell, 1884. Proc. Zool. Soc. London, p. 43
Type, *Echinanthus tumidus* Tenison-Woods, 1878. Proc. Linn. Soc. N. S. W., **2**, p. 169

It is difficult to determine whether one or two specimens of this highly interesting clypeastroid have been taken, for Bell's introductory paragraph is ambiguous on this point. Apparently, however, the specimen he studied was the holotype, now in the Australian Museum, Sydney, which is 140 mm. long, 115 mm. wide and 63 mm. high. No other specimen has been recorded since Bell's paper was published, but it is greatly to be hoped that further material will be secured for no clypeastroid gives so great promise of throwing light on the phylogeny of the group. It is unfortunate that the locality where the type was obtained is not known and that even its being from Australian waters is not past doubt.

Clypeaster.

Lamarck, 1801. Syst. Anim. sans Vert., p. 349.
Type, *Echinus rosaceus* Linné, 1758. Syst. Nat., ed. 10, p. 665.

It is not necessary to repeat here the discussion of the nomenclatural questions involved in making *rosaceus* the type of this genus; the details may be found in my paper already referred to (1911, Ann. Mag. Nat. Hist., ser. 8, 7). It may be well, however, to call attention to the fact that the ultimate settlement of the matter will depend not merely on whether pre-Linnean names are to be accepted but also on the interpretation of Linné's, Leske's, and Lamarck's references to the species involved. The number of recent species of Clypeaster is much larger than has hitherto been supposed. More than thirty-five species have been described, but as all but seven or eight of these were described before the Revision was published, and as Mr. Agassiz only recognized half a dozen species in that work, there has been an impression that there were not more than a dozen or fifteen valid species. Indeed in Bronn's Thier-reichs (1904) only eight species (grouped in three genera!) are admitted. My study of the large series of specimens in the M. C. Z. collection and the very interesting material gathered by the Albatross has convinced me that we should recognize at least nineteen species, of which three have not hitherto been described and one other requires a new name.

I have the pleasure of expressing here my most sincere thanks to Dr. Ludwig

Döderlein of Strassburg for the loan of specimens representing his Japanese species and for his kindness in answering questions and expressing opinions on the validity of certain forms. Through his kindness, I have been able to accept his opinion that the genus Alexandria of Pfeffer is a synonym of Clypeaster, being based apparently upon a specimen of the species here called *humilis*. And we are further agreed that *C. clypeus* and *C. excelsior* of Döderlein are synonyms of his *C. japonicus*. The clypeastroid described by Yoshiwara as *C. ogasawaraensis* is also *C. japonicus*. Dr. Seitaro Goto of the Imperial University, Tokyo, was so good as to have the type specimen sent to me and I am thus able to reach a positive conclusion. For his courtesy, I take pleasure in thanking Dr. Goto.

Owing to Loven's attempt (1887, Bih. K. Svenska Vet.-Akad. Handl., 13, afd. 4, no. 5, p. 171–176) to apply Linné's names *rosaceus* and *reticulatus* to species, with which they had never been associated, most unfortunate confusion has crept into the nomenclature of the genus. For this reason it has seemed to me important to give a certain amount of synonymy under the species which have long been known, especially since Loven's combinations and determinations have been incorporated into so widely used a text-book as Bronn's Thier-reichs.

Specific distinctions in the genus are based upon the form of the test, particularly with reference to the thickness of the margin and the ratio of length to breadth, upon the position of the anus, upon the form, relative length and openness of the petals, and upon the tuberculation of test, particularly as shown in the anterior ambulacrum, between the pore-pairs. These features are, of course, more or less variable, especially the form of the test, yet even in the most variable species there seem to be fairly well-defined limits. Few of the species are hard to recognize and it is probable that the number of valid species is larger rather than smaller than that listed here.

While the spines and pedicellariae are only of secondary importance in distinguishing the species of Clypeaster, so little has hitherto been published about them, that a few notes may be inserted here. The primary spines are usually smooth (Pl. 122, figs. *4, 9, 11*) but in *europacificus, rotundus* (Pl. 122, figs. *5, 6*), *subdepressus*, and *prostratus*, they are more or less rough or serrulate near the tip; in some other species serrations are often found near the tip of the larger primaries (Pl. 122, figs. *14, 15*). In *lamprus* (Pl. 122, figs. *1–3*), many oral primary spines are conspicuously elongated and broadly flattened at the tip, unlike any spines found in other species. In some species, notably *pallidus* (Pl. 122, fig.

16–18) the primary spines are spatulate or swollen at the tip, at least abactinally. In *ravenelii*, the primaries around the mouth (Pl. 122, figs. *12*, *13*) are noticeably modified. So far as the miliary spines are concerned, in *audouini*, *japonicus*, *leptostracon*, *rarispinus*, and *virescens*, they are more or less swollen or club-shaped at tip (Pl. 122, figs. *8*, *10*), while in all the other species they are cylindrical or terete (Pl. 122, fig. *7*), though in *lamprus*, and in individual cases in other species, some of them may approach the club-shaped form.

The *quadridentate* pedicellariae (Pl. 123, figs. *10*, *11*) have so far been found only in *ravenelii* and *subdepressus*, but they will probably be detected in some other species. Their valves (Pl. 123, fig. *7*) are narrow, compressed and meet only near the tip. The *tridentate* have been found in all of the nineteen species but they show considerable variety in form and in a few species (*audouini*, *australasiae*, *humilis*, *rotundus*) they seem to be very scarce. The valves may be broadly in contact (Pl. 123, figs. *20*, *21*, *29*) or meet only at the tip (Pl. 123, fig. *1;* Pl. 124, fig. *1*); they may be long and narrow throughout (Pl. 123, figs. *15*, *16*) or expanded at the tip (Pl. 123, figs. *2*, *3*, *12*, *19;* Pl. 124, figs. *2–6*), or broad and somewhat leaf shaped (Pl. 123, figs. *26*, *27*). In *lamprus*, the blade is almost tubular and only a little expanded at the tip (Pl. 123, fig. *22*). The *ophicephalous* pedicellariae (Pl. 123, fig. *17*) are less common than the tridentate in most species and were not found at all in *audouini*, *prostratus*, and *rotundus;* they were very scarce in *australasiae* and *humilis*. The opening of the blade (Pl. 123, figs. *4*, *28*) is broad and low and surrounded by conspicuous teeth. The loops vary much in size and form in the three valves of the same pedicellaria (compare Pl. 123, figs. *5* and *6* or figs. *13* and *14*). In many cases, the largest valve has a notable bihamate loop (Pl. 123, figs. *8*, *9*, *30*, *31*), and these hooks may even unite at the ends with the sides of the loop (Pl. 123, fig. *23*). The *triphyllous* pedicellariae (Pl. 123, fig. *18*) are so small they are difficult to find, and while they probably occur in all the species, I failed to find them in several. The valves (Pl. 123, figs. *24*, *25*) are broad and flat with finely serrate margins.

Key to the Species of Clypeaster.

Margin of test very thick, the upper surface rising so uniformly from ambitus to madreporite that a real margin can hardly be measured, but even in flattened individuals it is rarely less than .30 test-length; height of test rarely less than .35 test-length; lower surface of test deeply concave.

Test not evenly convex above, the median area of petals being more or less markedly elevated, not only above the poriferous areas but above the interambulacra also; pore-pairs in petals numerous (more than forty-five on each side in an unpaired

petal 22 mm. long); primary spines slightly and uniformly tapering to a blunt point; color more or less dark, reddish brown . . . . . *rosaceus.*

Test very evenly convex above, the petals scarcely at all elevated; pore-pairs much less numerous (thirty-nine on each side, in an unpaired petal 37 mm. long); primary spines acute, often enlarged just below tip; color light reddish . . . . *pallidus.*

Margin of test more or less distinct, its thickness usually less than .20 and often less than .10 test-length; height of test seldom exceeds .30 test-length.

Test about as wide as long, usually distinctly pentagonal with more or less concave sides, but sometimes the ambitus is circular; between ambitus and distal end of petals, the test is flat and its height there is only .03–.08 test-length; lower surface of test not at all concave.

Petals, especially unpaired one, broadly open at distal end.

Petals rather broad, the unpaired one being more than half as wide as long, the others somewhat narrower; poriferous areas parallel or somewhat diverging; tuberculation of test rather coarse (sixty–sixty primary tubercles to each sq. cm. of surface, aborally, near margin); margin somewhat swollen, its thickness about .08 test-length . . . . . *ravenelii.*

Petals narrower, width of unpaired one .40–.50 its length; poriferous areas converging distally; tuberculation of test less coarse; margin thin, not at all swollen, its thickness about .03–.04 test-length . . . . . *europacificus.*

Petals narrow, more or less closed at distal end.

Test moderately high (v.d. = .15–.20 test-length) with somewhat swollen margin (thickness = about .08 test-length); petaloid area rather more than .60 test-length . . . . . *audouini.*

Test very flat (v.d. hardly .15 test-length); margins not swollen, their thickness about .04 test-length; petaloid area .45–.55 test-length . . . *rarispinus.*

Test distinctly longer than wide, ambitus usually rounded but often pentagonal with nearly straight sides.

Test rather high (v.d. = .20–.35 test-length) with thick margins (thickness = .09–.22 test-length); aboral surface inclining upward more or less uniformly from margin (not in *reticulatus*); lower surface concave or (in *speciosus* and usually in *japonicus*) distinctly sunken only near mouth; tuberculation rather coarse (finer in *australasiae*) the ridges between pore-pairs of unpaired petal with only 4–6 (more in *australasiae*) or fewer primary tubercles.

Lateral petals more or less widely open.

Tuberculation rather coarse; pore-pairs in unpaired petal numerous (more than forty-five in a petal 33 mm. long), the ridges between narrow, each with a single series of four to six primary tubercles.

Test high (about .25 test-length), markedly concave beneath; color light yellowish brown . . . . . *ochrus.*

Test more flattened (about .20 test-length), slightly concave beneath; color deep purplish brown or blackish purple . . *speciosus.*

Tuberculation finer; pore-pairs not numerous (only about 45 on each side in a petal 56 mm. long); ridges between broad with 6–12 primary tubercles, often in double series . . . . . *australasiae.*

Lateral petals (at least anterior pair) more or less completely closed.

Size large, length up to 100 mm. and more; width exceeding .80

length; anterior petals more than .80 as long as unpaired one; lower surface not usually markedly concave, though mouth is distinctly sunken . . . . . *japonicus.*

Size small, not exceeding 75 mm. in length; width usually not .80 length; anterior petals short, scarcely .75 as long as unpaired one; lower surface strongly concave.

Unpaired petal widely open, with numerous pore-pairs (36 on each side in petal 10 mm. long); petaloid area not at all depressed . . . . . *lytopetalus.*

Unpaired petal nearly closed, with fewer pore-pairs (28 on each side in petal 14 mm. long); petaloid area in adult more or less depressed, at least the distal portion lying lower than the thickened test-margin though the apical system may be much higher *reticulatus.*

Test rather low (v. d. = .15–.22 test-length), with thin margins (.04–.08 test-length); aboral surface more or less flat distal to petals; lower surface flat or slightly and gradually concave.

Primary tubercles numerous, small; on each ridge between pore-pairs of unpaired petal, there is a single regular series of 6–15; unpaired petal with poriferous areas converging distally though petal may remain open.

Unpaired petal with relatively few pore-pairs (about 50 on each side in a petal 40 mm. long); median area of petals markedly obovate, narrow proximally and broadest distally; poriferous areas converging rather abruptly, and tending to close the petals, especially the anterior and posterior pairs . . . . . *humilis.*

Unpaired petal with more numerous pore-pairs (60–70 on a side in a petal 40 mm. long); median area of petals not obovate, usually as wide at the middle as anywhere; petals more or less open.

Test about .90 as wide as long or wider; anterior lateral petals about .90 as long as unpaired petal.

Unpaired petal broad and widely open; its breadth is decidedly more than half its length and it is at least twice as widely open as posterior pair . . . . . *prostratus.*

Unpaired petal narrower with poriferous areas more convergent; its breadth seldom exceeds half its length and is usually less; it is sometimes widely open but not more so than posterior pair . . . . . *rotundus.*

Test about .80 as wide as long; anterior lateral petals short, only about .80 as long as unpaired one . . . . . *subdepressus.*

Primary tubercles scattered, rather large especially on interambulacral areas orally; on each ridge between pore-pairs of unpaired petal, there are not more than four and often there is only one or none; unpaired petal short, only .25–.30 test-length, with poriferous areas parallel or somewhat diverging (in small specimens somewhat convergent).

Primary tubercles and their spines orally not strikingly peculiar; petals (at least in adults) much wider than half their length.

Test .90–.95 as wide as long, not depressed at distal end of petals; color, yellowish brown becoming deep green after

death and then gradually changing to brown, dull greenish, greenish yellow or pale buff . . . . . *virescens.*

Test about .80–.85 as wide as long, somewhat depressed distal to petals; color, yellow of several shades, with dusky markings, hardly changing at all after death . . . . . *leptostracon.*

Primary tubercles of interambulacra orally, very large and deeply sunken, bearing long spines which are conspicuously flattened and expanded at tip; petals in adults half as wide as long or less . . *lamprus.*

Clypeaster rosaceus.

Echinus rosaceus Linné, 1758. Syst. Nat., ed. 10, p. 665.
Clypeaster rosaceus Lamarck, 1801. Syst. Anim. sans Vert., p. 349.
Echinanthus rosaceus Gray, 1825. Ann. Phil., **26**, p. 427. A. Agassiz, 1872. Rev. Ech., pt. 1, p. 106.
Clypeaster reticulatus Lovén, 1887. Bih. K. Svenska Vet.-Akad. Handl., **13**, afd. 4, no. 5, p. 175.
Diplothecanthus reticulatus Duncan, 1889. Journ. Linn. Soc. Zool., **23**, p. 153. (Bronn's Thierreichs, 1904, **2**, abt. 3, buch 4, p. 1382).

Plate 123, fig. *1.*

This is a characteristic species of the West Indian region, ranging as far northward as Charleston, S. C.

Clypeaster pallidus, sp. nov.

Plates 122, figs. *16–18;* 123, figs. *2–4;* 139, figs. *1–3.*

Length 108 mm.; breadth, 85 mm.; height, 42 mm.; mouth sunken 22 mm. below sides of test. Test rather evenly convex, sloping uniformly from ambitus to apex; median areas of petals little elevated above pore-pairs and hardly at all higher than interambulacra. Tuberculation of test quite uniform; primary tubercles with sunken areolae, from 100 to 150 per sq. cm. of test surface aborally; ridges between pore-pairs of unpaired petal with a single series of 6–7 primaries; miliary tubercles six or seven times as numerous as primaries, low and granular. Madreporite stellate, 5 mm. across, the ocular plates and pores fairly distinct in the re-entrant angles. Genital pores moderately large, 1–2 mm. distant from the madreporite, in the interradii. Unpaired petal with 39 pore-pairs on each side, 37 mm. long, 19 mm. wide at middle, and 20 mm. wide, half way between middle and tip; the median area is 9 mm. and 10 mm. at the same two points respectively; hence the poriferous areas are about 5 mm. across where widest; the petal is open by fully 3 mm. Anterior petals somewhat

shorter and wider, about 36 by 21 mm. and about equally open at tip. Posterior petals longer and wider, 41 by 22 mm., about equally open. Periproct close to margin, about 5 mm. across, covered with numerous small, miliary bearing plates.

Primary spines of aboral surface, 2 or 3 mm. long, smooth, pointed, slightly flattened and often distinctly larger below the tip, thus becoming somewhat spatulate (Pl. 122, figs. *17*, *18*); on oral surface, the primaries are thicker, blunter, and longer, especially around the mouth (Pl. 122, fig. *16*). Miliary spines long, slender, and cylindrical or terete. Tridentate pedicellariae very common and large (heads = 1–1.6 mm.) on oral surface but rare and small (heads = .25–.75 mm.) aborally; the valves vary much in shape with their size. The small pedicellariae have broad, nearly straight valves, coarsely serrate on margin and meeting for nearly the full length of the blade; in larger ones, the valves are narrow and compressed, finely serrate along distal half of blade, where they meet; in the largest, the valves (Pl. 123, figs. *2*, *3*) are curved, dentate on margin, compressed and decidedly expanded at tip, where they meet. Ophicephalous pedicellariae common aborally, wanting on oral side; heads about .5 mm. long; opening of blade (Pl. 123, fig. *4*) broad and low, guarded by conspicuous teeth. Triphyllous pedicellariae rare, or at any rate, very hard to find; valves broad and flattened, about .07 mm. long, similar to those of *rotundus* (Pl. 123, fig. *25*).

Color aborally, light reddish; test yellowish brown when cleaned of the overlying red-brown skin; spines white or whitish, but with enough reddish tinge to give, with the skin, a general light reddish color; orally the skin is dull greenish yellow, while the spines are pale brown, with a reddish tinge. These are the colors of the holotype, dried after thirty years in alcohol; the color in life is not known.

A second, smaller specimen is very similar but the colors are paler, the test aborally is reddish and the primary tubercles are less numerous (4–6) on the ridges between the pore-pairs of the unpaired petal.

The holotype is from Blake St. 276, off Barbados, 94 fms.; the smaller specimen is from Blake St. 177, off Dominica, 118 fms.

These specimens were labelled "*E. rosaceus*," without critical examination, and were never subsequently examined until after Mr. Agassiz's death. When compared with specimens of *rosaceus* of the same size, the differences are so evident and seem to be so constant, I have not hesitated in considering this an undescribed species.

Clypeaster ravenelii.

Stolonoclypus ravenelii A. Agassiz, 1869. Bull. M. C. Z., **1**, p. 265.
Clypeaster ravenellii A. Agassiz, 1883. Mem. M. C. Z., **10**, p. 43.

Plates 122, figs. *12–14;* 123, figs. *5–10.*

In his account of the Blake Echini, Mr. Agassiz gives very satisfactory figures of this species; I have given here some additional figures to show the spines and pedicellariae. By an unfortunate misprint on p. 42 of his Blake report, Mr. Agassiz says that Pl. XI[c] of the Revision represents this species; that plate illustrates details of structure in the test of *C. rosaceus.* Apparently Mr. Agassiz intends to refer to Pl. XI[e] where there are two figures of a Clypeaster, labelled "*subdepressus,*" which resemble *ravenelii* to a certain extent, but which really represent *C. prostatus* Ravenel, a species Mr. Agassiz considered synonymous with *subdepressus.* The type of *ravenelii,* a young specimen, was taken among the Florida Keys; the Blake took specimens on the Yucatan Bank, Gulf of Mexico; near the Danish West Indies; and off Montserrat, Grenada and St. Vincent. The depths were 34–124 fms. The largest specimen is 132 mm. long, 136 mm. wide and 36 mm. high.; the concavity of the posterior side is 4 mm. The original type specimen is only 40 × 40 × 7 mm.

Clypeaster europacificus,[1] sp. nov.

Plates 123, figs. *13–16;* 129; 130; 131; 136, fig. *1.*

Length from distal margin of unpaired ambulacrum to distal margin of posterior interambulacrum, 165 mm.; greatest breadth, just posterior to antero-lateral ambulacra, 165 mm.; height, mouth to apex, 40 mm. Form pentagonal, with sides deeply concave; posterior side has the concavity 12 mm. deep; margins rather thin, about 7 mm. or not quite .06 test-length. Test highly arched in middle but rather flat distal to petals. Tuberculation of test rather coarse or better rather sparse; primary tubercles very small, with sunken areolae, about eighty per sq. cm. of test surface aborally; ridges between pore-pairs of unpaired petal, with a single series of seven or eight primaries; miliary tubercles fairly numerous, about ten times as many as primaries but not closely crowded. Madreporite pentagonal (in other specimens circular) with ocular plates and

[1] *Eurous* = eastern + pacificus, in allusion to its geographical distribution.

pores evident. Genital pores large, close to madreporite in interradii. Unpaired petal with about 56 pore-pairs on each side, 61 mm. long, 20 mm. wide at middle and only 21 mm. half way between middle and tip; median area 10 mm. wide with almost parallel sides; hence poriferous area rather more than five millimeters wide where widest; petal open by nearly 10 mm. Anterior petals 54 mm. long and 20 mm. wide, open by 5 or 6 mm. Posterior petals almost exactly identical with anterior. Periproct submarginal, small, scarcely 4 mm. across.

Primary spines rough at tip; those of aboral surface quite small, seldom exceeding 2 mm. in length; those of oral surface larger, near mouth about 4 mm. long or if short, much stouter than those of aboral surface. Miliary spines cylindrical or terete, quite numerous. Only ophicephalous and tridentate pedicellariae were found. The former have heads about .30 mm. long and stalks nearly twice as much; the valves (Pl. 123, figs. *13*, *14*) have the blades quite spinous at base, with the opening low and broad and the margin finely serrulate. The tridentate pedicellariae have the stalk about equal to the head; the valves are .15–.75 mm. long, narrow, straight, compressed and meeting for nearly half their length.

Color of holotype and other large specimens dull olive-green, brighter orally; smaller specimens are more red-brown or red-purple and very small specimens are quite distinctly reddish purple. In all the larger specimens, the ambulacra on the oral surface are darker than the interambulacra but the boundaries between the different areas are sharply zigzag lines, making rather of a handsome color-pattern, the distinctness of which varies greatly in the different specimens. The color in life is not known.

The holotype is from Albatross St. 2795, in the Gulf of Panama, 33 fms.

There is a very good series of this interesting and well-characterized clypeastroid, taken by the Albatross at various points in the eastern tropical Pacific. The smallest specimen is nearly circular in outline and only 6 mm. in diameter; of course its identification is not certain but I see no reason for questioning it. Others are 17, 26, 32, and 37 mm. in length, with the width practically the same; in these specimens the form is more pentagonal. The largest specimen is 196 mm. across but the length in the antero-posterior axis is only 191 mm.; the concavity of the posterior side is however 12 mm. The color of this specimen is, like that of the type, very distinctly olive-green, but there is good reason for believing that this is due to the copper can in which they were stored for many years; their labels are very green. The other specimens are all more or

less reddish purple, which is probably nearly the color in life. While this species resembles *ravenelii* in form, it is not so heavy and the test-margin is very much thinner. Moreover the petals are very different, so that the two species cannot be confused.

The ALBATROSS took *europacificus* at the following places:—

Station 2795. Gulf of Panama, 7° 57′ N., 78° 55′ W. Bott. temp. 64.1°. 33 fms. Gy. s., bk. sp., brk. sh.

Station 2813. Northwest of Hood Island, Galapagos, 1° 21′ S., 89° 40′ 15″ W. Bott. temp.? 40 fms. Co. s.

Station 2829. Off Cape St. Lucas, L. Cal., 22° 52′ N., 109° 55′ W. Bott. temp. 74.1°. 31 fms. Rky.

Station 2995. Off Clarion Island, 18° 19′ N., 116° 44′ 15″ W. Bott. temp. 68.4°. 31 fms. Gy. s., brk. co.

Station 3014. Gulf of California, 28° 28′ N., 112° 04′ 30″ W. Bott. temp. 62.9° 29 fms. Gy. s.

Station 3390. Off Cape Mala, Panama, 7° 26′ 10″ N., 79° 53′ 50″ W. Bott. temp. 62.6°. 56 fms. Fne. gy. s., gr.

Bathymetrical range, 29–56 fms. Extremes of temperature, 74.1°–62.6°.

Fifteen specimens.

Clypeaster audouini.

Fourtau, 1904. Bull. Inst. Egypt, ser. 4, **4**, p. 418.

Plates 122, fig. *10;* 123, fig. *24*.

As Fourtau gives no details concerning spines and pedicellariae; it may be mentioned here that the primary spines are smooth and the miliaries have conspicuously club-shaped tips (Pl. 122, fig. *10*). Pedicellariae are exceedingly scarce in the three specimens at hand. The single tridentate found had valves .36 mm. long, shaped somewhat like those of *rotundus* (Pl. 123, fig. *27*) but with the blade a trifle more angular on each side and not so evenly rounded. The triphyllous had valves .09 mm. long and quite broad and flat (Pl. 123, fig. *24*). This species is very well characterized. It appears to be distributed along the whole East African coast for while Fourtau's specimens were from the Red Sea, those of the M. C. Z. collection are from Natal.

Clypeaster rarispinus.

De Meijere, 1903. Tijdsch. Nederland. Dierk. Ver., ser. 2, 8, p. 7.

The only addition I have to make to de Meijere's account is the presence of ophicephalous pedicellariae, which he did not find. They are small (heads only .15–.20 mm. long) and not at all common. The triphyllous pedicellariae have valves only .07 mm. long, but the stalk is seven times as long as the head. In the tridentate the valves are curved, .43 mm. long and have the blade gradually widened near tip. They are thus somewhat like those of *audouini*, and the miliary spines are much like those of that species. The SIBOGA took *rarispinus* at four stations in the Dutch East Indies and it is not yet known from elsewhere.

Clypeaster ochrus,[1] sp. nov.

Plate 141, figs. *1–3*.

Length, 94 mm.; breadth, 83 mm.; height, 24 mm.; mouth sunken 12 mm. below sides of test. Test moderately high and rather evenly arched, deeply concave beneath; margins 8–9 mm. thick or rather more than .08 of test length. Tuberculation of test, rather coarse; primary tubercles small, with sunken areolae, about 100 per sq. cm. of test surface, aborally; ridges between pore-pairs of unpaired petal with a single series of four to six primaries; miliary tubercles very numerous, probably twenty times as many as primaries, covering the test quite uniformly. Madreporite pentagonal, 4 mm. across; ocular plates and pores not very distinct. Genital pores large, close to interradial angles of madreporite. Unpaired petal with about fifty-three pore-pairs on each side, 32 mm. long, 15 mm. wide at middle, and 16.5 mm. wide half way between middle and tip; median area, 9 mm. and 10 mm. at the same two points respectively; hence poriferous areas about 3 mm. across where widest; petal open by fully 5 mm. Anterior petals somewhat shorter and wider, about 30 by 18 mm., not quite so open at tip. Posterior petals as long as unpaired and as broad as anterior; open by about 4 mm. Periproct 3 mm. from margin about 5 mm. across, covered with numerous small, miliary bearing plates.

Primary spines of aboral surface, rather slender, perfectly smooth, about 2 mm. long; on oral surface, primaries longer especially about mouth where they are 4 mm. long. Miliary spines cylindrical or terete, not peculiar, but

[1] ὠχρός = pale, sallow, in allusion to its light yellow-brown color.

slender and very numerous. Pedicellariae common; tridentate have valves .15–.80 mm. long with rather broad blades, like those of *rotundus* (Pl. 123, fig. *27*); ophicephalous have heads about .20 mm. long; triphyllous have valves about .06 mm. long, somewhat narrower apparently than in *rotundus* (Pl. 123, fig. *25*).

Color aborally, yellowish brown; orally reddish brown; primary spines near mouth with a very faint dusky band about middle. Color in life not known; the description is from a specimen dried after forty years in alcohol.

A second larger specimen is 112 mm. long, 92 mm. wide, 30 mm. high, with mouth sunken 15 mm. The color is not essentially different but the dusky band on the oral primaries is more distinct. The test margin is 11 mm. thick or about .10 test-length.

Both specimens were collected at Acapulco, Mexico, by the HASSLER expedition in 1872.

These specimens bear no other label than "Clypeaster" and were apparently never identified by Mr. Agassiz. The form and color distinguish them so easily from the numerous specimens of *speciosus* which I have seen from Lower California that I have been unwilling to consider them that species, although no other differences of importance have been found. More material may show that *ochrus* is only a local form of *speciosus* but for the present it seems better to consider them distinct.

Clypeaster speciosus.

Verrill, 1870. Amer. Journ. Sci., ser. 2, **49**, p. 95.

Plates 122, fig. *11*; 128, fig. *7*; 135, figs. *1*, *2*; 136, fig. *5*.

Although Mr. Agassiz considered this species identical with the following, the differences between them are very constant and I cannot refuse to recognize each as a valid species. The difference in tuberculation of the test is well shown on Pl. 128, in figs. *4* and *7*. Neither primary nor miliary spines in *speciosus* are peculiar. Pedicellariae are common and all three kinds occur; they are similar to those of *rotundus*, except that the valves of the triphyllous seem to be a little more elongated in proportion to their width.

The ALBATROSS collected *speciosus* at the following points: —

Station 2824. Gulf of California, 24° 22′ 30″ N., 110° 19′ 30″ W. 8 fms. Brk. sh.

Station 2826. Gulf of California, 24° 12′ N., 109° 55′ W. 9.5 fms. Sh.
Station 2828. Gulf of California, 24° 11′ 30″ N., 109° 55′ W. 10 fms. Sh.
Bathymetrical range, 8–10 fms.
Three specimens.

Clypeaster australasiae, comb. nov.

Echinanthus australasiae Gray, 1851. Proc. Zool. Soc. London, p. 34.
Echinanthus testudinarius A. Agassiz, 1872. Rev. Ech., pt. 1, p. 106. H. L. Clark, 1909. Mem. Austr. mus., **4**, p. 558.
Plesianthus testudinarius Duncan, 1889. Journ. Linn. Soc. Zool., **23**, p. 155.

Plates 128, fig. *4;* 134, figs. *1–3;* 135, fig. *6*.

This species is apparently confined to the Southeastern coasts of Australia, for there are as yet no reliable records from elsewhere. The spines show no peculiarities. The pedicellariae are very scarce and show no characteristic features. Only one ophicephalous, and half a dozen tridentate were found; the head of the former was about .40 mm. long, while the valves of the tridentate ranged from .15 to .85 mm.

Clypeaster japonicus.

Döderlein, 1885. Arch. f. Naturg., **51**, 1, p. 100.

Clypeaster clypeus Doderlein, 1885. Arch. f. Naturg., **51**, 1, p. 100.
Clypeaster excelsior Doderlein, 1885. Arch. f. Naturg., **51**, 1, p. 101.
Plesianthus ogasawaraensis Yoshiwara, 1898. Ann. Zool. Jap., **2**, p. 60.

Plates 128, fig. *5;* 136, figs. *2–4;* 138, fig. *5*.

This seems to be the common clypeastroid of Japanese waters. Although it has usually been confused with one or the other of the two preceding species, it is really quite distinct. It is rather variable, particularly in the form of the test (compare Pl. 136, figs. *2–4*, with Pl. 138, fig. *5*) and this has led to the description of the several species mentioned in the synonymy. With Yoshiwara's type specimen of *Plesianthus ogasawaraensis* at hand for comparison I see no reason for doubting that it is *japonicus*. The color differences have wholly disappeared in alcohol and even in life are not very striking, so that I cannot feel they are of much importance. As I have stated above (p. 21), Dr. Döderlein has very kindly loaned me specimens of his Japanese species and we are agreed in considering *clypeus* and *excelsior* as synonyms of *japonicus;* they are based

on individual variants. In regard to retaining the name *japonicus* instead of *clypeus*, which precedes it on the page, the choice is determined by the fact that *clypeus* is based on a single *atypical* specimen while *japonicus* is based on a series of specimens. Moreover the name *japonicus* is to be preferred, as more appropriate. As the International Code simply recommends the adoption of "page precedence" "other things being equal," I have thought best to retain *japonicus*, as other things are not equal.

In conclusion, it may be mentioned that the primary spines are smooth and the miliaries are club shaped. Pedicellariae are abundant but no triphyllous were noted. Many tridentates are very small, the valves less than .15 mm. long, but they range up to 1.10 mm.; the valves show an equal diversity in slenderness, the length of the heads ranging from 1.5 to 2.25 times its thickness at base. The ophicephalous pedicellariae occur chiefly near the ambitus and have heads .30 mm. long, more or less.

Clypeaster lytopetalus.[1]

A. Agassiz and Clark, 1907. Bull. M. C. Z., 50, p. 248.

Plates 124, figs. *1*, *2*; 138, figs. *1–3*.

Length, 33 mm.; breadth, 26 mm.; height, 10 mm.; mouth sunken 3.5 mm. below sides of test. Test evenly convex, sloping uniformly from ambitus to apex. Tuberculation of test rather coarse, about a hundred primary tubercles to a sq. cm. of surface; these tubercles are relatively large with sunken areolae; ridges between pore-pairs of unpaired petal, with only one primary tubercle or none; miliary tubercles numerous but very small and often only faintly indicated. Madreporite pentagonal, 1.5 mm. across; ocular plates and pores distinct but genital pores wanting. Unpaired petal, with thirty-six pairs of pores on each side, 10 mm. long, 5 mm. wide at middle and 6 mm. wide, half way between middle and tip; median area 3 and 4 mm. wide at same two points respectively; hence poriferous areas are about 1 mm. across where widest; petal open by fully 2.5 mm. Anterior petals only 8 mm. long, but 6 mm. wide, closed at tip. Posterior petals 9.5 mm. long and 6 mm. wide, slightly open at tip. Periproct very near margin about 2 mm. across, covered with 25–30 plates, most of which bare one miliary spine (rarely two).

Primary spines, smooth, slender; on aboral surface hardly more than a

[1] λύτο from λύω = to open + πέταλον = petal, in reference to the open, unpaired petal.

millimeter long, but aborally two to three times that. Miliaries very slender, not at all club shaped. Pedicellariae fairly common, but no triphyllous were found. Ophicephalous have heads about .35 mm. long. Tridentate (Pl. 124, fig. 1) have heads about .70 mm. long, the blade of the valves abruptly expanded near tip (Pl. 124, fig. *2*).

Color dark yellowish brown, in the holotype, dried from alcohol. · A second smaller specimen is bright reddish brown.

The holotype is from Station 3962.

The difference in the shape of the test between this species and the next is very noticeable. The absence of genital pores even in the larger specimen shows that we have as yet only young individuals of *lytopetalus*. As genital pores are present in specimens of *reticulatus* when they are 15 mm. long, or about one third grown, it is possible the adult of *lytopetalus* reaches a length of at least 100 mm.

The ALBATROSS took *lytopetalus* at the following places:—

Station 3936. Off Laysan Island, Hawaiian Islands. Bott. temp. 68°. 79–130 fms. Sml. brk. sh., corln.

Station 3962. Off Laysan Island, Hawaiian Islands, Bott. temp.? 16 fms. Wh. s., co.

Two specimens.

Clypeaster reticulatus.

Echinus reticulatus Linné, 1758. Sys. Nat. ed. 10, p. 666. (pars).
Echinodiscus reticulatus Leske, 1778. Add. ad Klein, p. 143.
Clypeaster reticulatus Desmoulins, 1837. Études sur les Éch.: Tab. Syn. p. 214.
Clypeaster scutiformis Lamarck, 1816. Anim. sans Vert., **3**, p. 14. A. Agassiz, 1872. Rev. Ech., pt. 1, p. 101, *et auct. seq.*

Plate 124, figs. *3–6*.

Although this is one of the best known species of the genus nothing has hitherto been published concerning the spines and pedicellariae, except de Meijere's account in his report on the SIBOGA Echini (1904). While there is little to add to that account, it is worth while to call attention to the variability of the tridentate pedicellariae not only in size but in the shape of the valves. De Meijere says the valves range from .075 to .375 mm.; those I have examined range from .30 to .60 mm. In a specimen from Reunion the blade is much widened and rounded at tip (Pl. 124, fig. *3*) but in a superb specimen from Mauritius, it is less widened and is distinctly pointed (Pl. 124, fig. *4*). In a young

specimen from Hawaii, the form is somewhat intermediate between these two (Pl. 124, fig. 5), while in an adult Hawaiian specimen the blade is more gradually expanded than in any of the others (Pl. 124, fig. 6). The difference between this latter and the form found in the specimen from Reunion led me at first to suppose they were different species but thorough examination of their other characters and examination of the tridentate pedicellariae in a number of other specimens compelled me to conclude that in this species these pedicellariae are very variable. The two specimens from Mauritius are notable, not only for their peculiar pedicellariae but for their size; the larger is 73 mm. long, 59 mm. wide, 19 mm. high and the margins of the test are 16 mm. thick. In the Revision 48 mm. is given as the maximum length for the species.

The ALBATROSS collected this species at numerous stations in the Hawaiian Islands, but most of the specimens are young and a good many are bare tests They range from 13 to 45 mm. in length.

Station 3846. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 71.5°. 60–64 fms. Crs. br. s., sh., gr.

Station 3847. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. ? 23–24 fms. S., st.

Station 3848. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 71.1°. 44–73 fms. S., gr.

Station 3849. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 67.6°. 43–73 fms. Crs. s., brk. sh., co.

Station 3850. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 71.7°. 43–66 fms. Crs. s., brk. sh., co.

Station 3863. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 60°–61°. 127–154 fms. Brk. co., ers. g., r.

Station 3871. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp.? 13–43 fms. Fne. wh. s.

Station 3872. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 74.6°. 32–43 fms. Yl. s., p., co.

Station 3874. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 75.3°. 21–28 fms. S., p., sh.

Station 3876. Off Lahaina Light, Maui, H. I. Bott. temp. 74°. 28–43 fms. S., g.

Station 3962. Off Laysan Island, H. I. Bott. temp.? 16 fms. Wh. s., co.

Station 3982. Off Nawiliwili Light, Kauai, H. I. Bott. temp. 48.5°. 233–400 (?) fms. Crs. br. co., s., sh.

Station 3987. Off Hanamaulu, Kauai, H. I. Bott. temp. 73°. 50–55 fms. Crs. co. s., co. frgs.

Station 4031. Off Diamond Head, Oahu, H. I. Bott. temp.? 27–28 fms. Fne. co. s., for., co.

Station 4032. Off Diamond Head, Oahu, H. I. Bott. temp.? 27–29 fms. Fne. co. s., for.

Station 4033. Off Diamond Head, Oahu, H. I. Bott. temp.? 28–29 fms. Fne. co. s., for.

Station 4034. Off Diamond Head, Oahu, H. I. Bott. temp.? 14–28 fms. Fne. co. s., for.

Station 4061. Off Kauhola Light, Hawaii, H. I. Bott. temp.? 24–83 fms. Co. s., corln. nod., for.

Station 4128. Off Hanamaulu, Kauai, H. I. Bott. temp. 47.8°. 68–253 fms. Crs. br. co. s., for.

Station 4146. Off Modu Manu, H. I. Bott. temp. 78.7°. 23–26 fms. Crs. co. s., for.

Station 4148. Off Modu Manu, H. I. Bott temp. 77.9°. 26–33 fms. Co. s., for.

Station 4150. Off Modu Manu, H. I. Bott. temp. 74°. 71–160 fms. Co.

Station 4158. Off Modu Manu, H. I. Bott. temp. 78.6°. 20–30 fms. Co., corln.

Station 4164. Off Modu Manu, H. I. Bott. temp. 78.1°. 40–56 fms. Co. s., p., sh.

Wotje, Marshall Islands.

Taritari, Gilbert Islands.

Bathymetrical range, 13–253 fms. Extremes of temperature, 78.7°–47.8°.

One hundred and seventy-one specimens.

Clypeaster humilis.

Echinanthus humilis Leske, 1778. Add. ad Klein, p. xix, 121.

Clypeaster humilis A. Agassiz, 1872. Rev. Ech., pt. 1, p. 100

Clypeaster placunarius Agassiz and Desor, 1847. Ann. Sci. Nat., ser. 3, **7**, p. 130: non *Scutella placunaria* Lamarck, 1816.

Clypeaster rosaceus Lovén, 1887. Bih. K. Svenska Vet.-Akad. Handl., **13**, afd. 4, no. 5, p. 173: non *Echinus rosaceus* Linne, 1758, *Clypeaster rosaceus* Lamarck, 1801.

Alexandria magnifica Pfeffer, 1881. Verh. Naturw. Ver. Hamburg-Altona im 1880, p. 64.

Plates 123, fig. *23*; 137; 138, fig. *4*.

Although this is very possibly the best known species in the genus, its name

is difficult to determine and it is only after much deliberation that I have decided to use the name first given by Leske and later used by Mr. Agassiz in the Revision. It seems to be true that in a general way *Echinanthus humilis* Leske is a synonym of *Echinus rosaceus* Linné but as soon as Lamarck in 1801 definitely restricted *rosaceus* to the West Indian form with which that name has since been associated, *humilis* was no longer synonymous with it except in small part and hence it is permissible to use *humilis* for one of the forms included by Leske under that name. Certainly Lovén seems to be wrong in attempting to apply Linné's name *rosaceus* to this species, since Lamarck long ago restricted it to the West Indian form, but he seems to be quite right in maintaining that Lamarck's *Scutella placunaria* is not a Clypeaster at all and therefore the name *placunarius* cannot be correctly used for this species, even if we reject *humilis*. Dr. Döderlein tells me, and I am quite ready to agree with him, that Pfeffer's *Alexandria magnifica*, which has been a puzzle to systematists, is based on a fine alcoholic specimen of this Clypeaster.

The abactinal primary spines of this species tend to be small, rough, and slightly enlarged near the tip; the miliaries are not peculiar. Pedicellariae seem to be quite rare for on one specimen, one ophicephalous pedicellaria was all I could find and there were no tridentate, while on another specimen, tridentate were found but not an ophicephalous. The head of the ophicephalous was about .40 mm. long and the loops on the valves, particularly on the largest, were remarkably big (Pl. 123, fig. *23*). The valves of the tridentate are about .90 mm. long, narrow but broadly expanded at tip somewhat like fig. *2*, Pl. 124. The known geographical range of *humilis* is from the Red Sea and Mauritius to the East Indian Islands.

Clypeaster prostratus.

Scutella gibbosa Ravenel, 1845. Proc. Acad. Nat. Sci. Philadelphia, **2**, p. 253, non Risso, 1826, Hist. Nat., p. 284.

Clypeaster prostratus Ravenel, 1848. Ech. Rec. Foss. South Carolina, p. 3.

Clypeaster subdepressus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 101 (pars); Pl. xi[e], figs. 1, 2.

Examination of two fine specimens in the M. C. Z. collection, one from South Carolina and one from Georgia, has satisfied me that this species is perfectly distinct from the West Indian *subdepressus*. The form of the test and the appearance of the petals are very characteristic features, well shown in Mr. Agassiz's figures. The spines and pedicellariae are similar to those of *subdepressus* except that the tridentate are the only pedicellariae found and their valves are

broader, straighter, and more acuminate than those of *subdepressus;* their length is .35–1.00 mm. In 1911 (Ann. Mag. Nat. Hist., ser. 8, **7**, p. 595) I named this species as the type of Agassiz's genus Stolonoclypus should it ever be desirable or necessary to use that genus, and added that *prostratus* was a synonym of *subdepressus.* It now seems that *prostratus* can stand on its own merits and hence is itself the type-species of Stolonoclypus.

Clypeaster rotundus.

Stolonoclypus rotundus A. Agassiz, 1863. Bull. M. C. Z., **1**, p. 25.
Clypeaster rotundus A. Agassiz, 1872. Rev. Ech., pt. 1, p. 100.

Plates 122, figs. *5–7;* 123, figs. *25–27;* 128, fig. *6;* 132; 133.

This fine species is the West coast representative of *prostratus* and is really nearer that species than it is to *subdepressus.* It is readily distinguished from the other West coast species by the shape of the petals and the fine tuberculation of the test (Pl. 128, fig. *6*). The Albatross took a single specimen of *rotundus* at Station 2796, Gulf of Panama, 33 fms., and as it is a particularly fine one, and the species has never been figured, I have given here photographs of it (Pls. 132, 133).

The primary spines of *rotundus* are more or less rough or serrulate, and the abactinal ones (Pl. 122, figs. *5, 6*) are slightly expanded at tip. The miliary spines (Pl. 122, fig. *7*) are cylindrical or terete. Pedicellariae seem to be sometimes very scarce, as in one specimen only three minute tridentate and one triphyllous were found. The valves of the tridentate (Pl. 123, figs. *26*) are only about .15 mm. long and are notably broad. In another specimen there were a number of tridentate pedicellariae with valves over .60 mm. long and a more usual style of blade (Pl. 123, fig. *27*). In a third specimen, ophicephalous pedicellariae were found but they showed no peculiarities.

Clypeaster subdepressus.

Echinanthus subdepressa Gray, 1825. Ann. Phil., **26**, p. 427.
Clypeaster subdepressus Agassiz, 1836. Mem. Soc. Sci. Nat. Neuchatel, **1**, p. 187.

Plate 123, figs. *11, 12.*

The presence of quadridentate pedicellariae (Pl. 123, figs. *11, 12*) is one of the characteristics of this West Indian species. The valves of these pedicellariae are .45–1.00 mm. long and very narrow, but slightly expanded at the tip. The

tridentate pedicellariae are smaller and are quite rare, as are the ophicephalous, with heads about .30 mm., and the triphyllous, whose valves are only .075 mm. long.

A specimen of *subdepressus* in the M. C. Z. collection is the largest clypeastroid I have seen or found recorded; it is 248 mm. long and 214 mm. wide. It is labelled "*Lagana latissima* Blainville" and is probably identical with Lamarck's *Scutella latissima*, in which case that name is synonymous with *subdepressus* rather than with *humilis*.

Clypeaster virescens.

Döderlein, 1885. Arch. f. Naturg., **51**, 1, p. 102.

Plates 122, fig. *15;* 123, figs. *28–31;* 128, fig. *8;* 139, fig. *4;* 140, figs. *1–2*.

This is a remarkably well characterized species which has not hitherto been figured. The series of specimens collected by the Albatross ranges from 13 to 112 mm. in length. All have the characteristic yellow-green color, though the depth of the shade differs much in different specimens. The primary spines are nearly smooth, but under high magnification the marginal ones show some serrations (Pl. 122, fig. *15*). The miliaries are mostly more or less club shaped. Some of the actinal primaries, especially those near margin are 4–5 mm. long. Ophicephalous and tridentate (Pl. 123, fig. *29*) pedicellariae are abundant. The former have heads .40–.50 mm. long; the blades have wide, low, curved openings (Pl. 123, fig. *28*) while the loops are often, or of the largest valve always, more or less bihamate (Pl. 123, figs. *30*, *31*). The tridentate valves range from .25–1.00 mm. in length; they are rather straight and compressed and the blades meet at tip for half their length.

This species is known only from Japanese waters. The Albatross collected it at the following places:—

Station 4877. Eastern Channel, Korea Strait. Bott. temp. ? 59 fms. Fne. gy. s., brk. sh.

Station 4884. Between Nagasaki and Kagoshima, Japan. Bott. temp. 61.7°. 53 fms. Dk. gy. s., brk. sh.

Station 4885. Between Nagasaki and Kagoshima, Japan. Bott. temp. 61.7°. 53 fms. Dk. gy. s., brk. sh.

Station 4893. Southwest of Goto Islands, Japan. Bott. temp. 55.9°. 95–106 fathoms. Gy. s., brk. sh., p.

Station 4894. Southwest of Goto Islands, Japan. Bott. temp. ? 95 fms. Gy. s., brk. sh., p.

Station 4895. Southwest of Goto Islands, Japan. Bott. temp.? 95 fms. Gy. s., brk. sh., p.

Station 4937. Kagoshima Gulf, Japan. Bott. temp. 64.8°. 58 fms. M., lava, p.

Station 4948. Between Kagoshima and Kobe, Japan. Bott. temp. 62.6°. 65 fms. Dk. gy. vol. s., brk. sh., p.

Station 5071. In Suruga Gulf, Japan. Bott. temp. 70.8°. 87 fms. Char. of bott.?

Station 5095. Gulf of Tokyo, Japan. Bott. temp. 57.8°. 58 fms. Fne. bl. s., br. sh.

Bathymetrical range, 53–106 fms. Extremes of temperature 70.8°–55.9°.

Fourteen specimens.

Clypeaster leptostracon.[1]

A. Agassiz and Clark, 1907. Bull. M. C. Z., **50**, p. 248.

Plates 122, figs. *8*, *9*; 123, figs. *17–20*; 135, figs. *3–5*.

Length 38 mm.; breadth, 31 mm.; height, 7.5 mm.; mouth sunken but very little below the sides of the test. Test quite flat distal to petals, the margin a trifle thicker than the test a little ways in from the margin; petaloid area abruptly elevated; orally the test is flat, the region about the mouth slightly concave. Tuberculation of test sparse; primary tubercles relatively large with sunken areolae, less than 100 to a square centimeter of test surface, aborally; ridges between pore-pairs of unpaired petal with no primaries or occasionally a single one; miliary tubercles fairly numerous, not crowded and rather evenly distributed. Madreporite pentagonal, 2 mm. across, the ocular plates and pores fairly distinct; genital pores present only in interambulacra 2 and 4, close to madreporite. Unpaired petal with 24 pore-pairs on each side, 9 mm. long, 5.5 mm. wide near tip, open by more than 3 mm.; median area 3–3.5 mm. wide; poriferous areas thus 1 mm. wide each. Anterior petals 7.5 mm. long, open by only 1 mm., their greatest width, 4.75 mm., a little further from tip than in unpaired petal. Posterior petals 8.5 mm. long, 5 mm. wide, open by about 2 mm., their form much like that of unpaired petal. Periproct 2 mm. from margin, about 2 mm. across, covered with miliary bearing plates.

[1] λεπτός = delicate + ὄστρακον = shell, in allusion to the thinness of the test-wall.

Primary spines smooth and pointed (Pl. 122, fig. *9*), some of the marginal, actinal ones nearly 3 mm. long. Miliary spines usually club shaped (Pl. 122, fig. *8*), but many are not evidently so. Pedicellariae only fairly common and not particularly characteristic. Triphyllous (Pl. 123, fig. *18*), very small with valves only .06 mm. long. Ophicephalous (Pl. 123, fig. *17*) with heads .25–.30 mm. long and rather slender valves. Tridentate (Pl. 123, fig. *20*) with straight valves, more or less in contact, and ranging from .10 to .60 mm. in length; the larger ones (Pl. 123, fig. *19*) have the blade expanded rather abruptly near tip and the margin serrate; there is often a more or less imperfect loop on the base of these valves.

In color the specimens (in alcohol) vary from bright yellow or reddish yellow to dirty purplish white; in dry specimens the colors are duller. The yellow specimens have a large number of rather indistinct, dusky blotches on the aboral surface; these are arranged in pairs, four pairs in each ambulacrum and interambulacrum, and form four concentric circles around the petals, parallel to the ambitus. In all the specimens there is more or less contrast in color between the ambulacra and interambulacra on the oral surface. The colors in life are not essentially different.

The holotype is from Station 4046.

When young specimens of *virescens* of the same length as the type of *leptostracon* are compared with it, the differences in the form of the petals and especially in the form of the test are very marked. The difference in color is also marked. There is no doubt that the two species are perfectly distinct. The series of *leptostracon* at hand is a very complete one, the specimens ranging from 5.5 mm. in length up to the type, which is seven times as large. In specimens under 15 mm. in length the aboral side of the test has numerous deep, irregular pits in the surface; in the smallest specimen these occur everywhere except close to the madreporite, but as the petaloid area grows, the pits are confined more and more to the marginal part of the test and they finally disappear altogether. In the youngest specimen, there are but three or four pore-pairs in each petal and the resemblance to Echinocyamus is marked but there are at least ten madreporic pores, instead of the one, characteristic of that genus.

The Albatross took *leptostracon* at the following places:—

Station 3823. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 69°. 78–222 fms. Fne. s., p.

Station 3987. Off Hanamaulu, Kauai, H. I. Bott. temp. 73°. 50–55 fms. Crs. co. s., co. frgs.

Station 4046. Off Kawaihae Light, Hawaii, H.I. Bott. temp. 59°. 71–147 fms. Co. s., for.

Station 4064. Off Kauhola Light, Hawaii, H. I. Bott. temp. 69°. 63–107 fms. Vol. s., for., co.

Station 4066. Off Ka Lae-o Ka Ilio Point, Maui, H. I. Bott. temp. 52.5°. 49–176 fms. Rky.

Bathymetrical range, 49–222 fms. Extremes of temperature, 73°–52.5°.

Fifty-seven specimens.

Clypeaster lamprus,[1] nom. nov.

Clypeaster latissimus A. Agassiz, 1883 Mem. M. C. Z., **10**, p. 41. Non *C. latissimum* A. Ag., 1872. Rev. Ech. pt. 1, p. 101.

Plates 122, figs. *1–4;* 123, figs. *21, 22.*

This is one of the best defined and most easily recognized species in the genus but as it is certainly not the *Laganum latissimum* of Agassiz and Desor, 1847, it cannot be called "*Laganum latissimum* Hupé, 1856," even if it be granted that Hupé had specimens of this species as the basis for his name. And it is almost certain that Hupé never saw this species which was collected by the Blake at five stations in the Lesser Antilles in 88–120 fms. The figures given by Mr. Agassiz (1883, Mem. M. C. Z., **10**, pls. XV[b], fig. 3; and XV[c], fig. 3) show the characteristic features admirably, but certain additional details deserve mention.

The abactinal primaries are smooth, pointed and many, especially of the larger ones near apex of test, tend to be spatulate. The actinal primaries are more diversified; the small ones (Pl. 122, fig. *4*) are often curved, while the larger ones may be doubly curved (Pl. 122, fig. *2*) and spatulate (Pl. 122, fig. *3*) and the largest, which may be 10–12 mm. long, are curved and broadly expanded at tip (Pl. 122, fig. *1*). Pedicellariae are very common; the triphyllous are very small with valves only .07 mm. long while the ophicephalous have heads .40 mm. long, with valves much like those of *virescens*. The tridentate pedicellariae are of two kinds although these intergrade to some extent; the small ones (Pl. 123, fig. *21*) are not peculiar or characteristic, but the large one, with curved valves up to .80 mm. in length (Pl. 123, fig. *22*), are unlike any that are known in other Clypeasters; the blade has the margins much incurved, thus tending to become tubular and the valves meet only at the tip.

[1] Λαμπρός = splendid, magnificent

ARACHNOIDIDAE Gregory.

This family is maintained for a single, monotypic genus, remarkable for the flatness of its test, the divergent petaloid areas, the supramarginal periproct, the separate auricles and a plated buccal membrane.

Arachnoides.

Leske, 1778. Add. ad Klein, p. viii and p. 154.

Type, *Arachnoides echinarachnius* Leske, *l. c.*, = *Echinus placenta* Linné, 1758. Sys. Nat., ed. 10, p. 666.

(For a discussion of the nomenclatural questions involved in dating this genus from Leske, see Clark, 1911, Ann. Mag. Nat. Hist., ser. 8, **7**, p. 598).

Arachnoides placenta.

Echinus placenta Linné, 1758. Sys. Nat., ed. 10, p. 666.
Arachnoides placenta Agassiz, 1841. Mon. Scut., p. 91.

Plate 125, figs. *1–3*.

Little need be said of this well-known species, but attention may well be called to the fact that the pedicellariae which are very scarce and which de Meijere calls tridentate, in reality have only *two* valves (Pl. 125, fig. *2*); these valves measure .12–.25 mm. in length, are rather broad (Pl. 125, fig. *1*) and are serrate and toothed at tip (Pl. 125, fig. *3*) where they meet. Many spines, especially among the abactinal primaries, have asymmetrical swollen tips like that figured by de Meijere (1904) for Echinodiscus. The geographical distribution of Arachnoides is remarkable for while it is common in New Zealand as far south as Dunedin, and on the Australian coast, and reaches Samoa on the east and the Malay Peninsula and Burmah on the north, it is not known from either the western or the northeastern parts of the Indo-Pacific region. Very few echinoderms are common to the Malay Peninsula and New Zealand, and no other case is satisfactorily demonstrated.

LAGANIDAE A. Agassiz.

Although the superficial resemblance of the members of this family to Clypeaster is marked, more careful examination shows that the differences are far more important and indicate that there is no very close relationship. The

test of the Laganidae is usually very flat and it is never highly arched although it is occasionally moderately thick and concave beneath. The primary spines are not peculiar, but are solid, slender, and pointed, while the secondaries are characteristic, as already described (p. 14). All three kinds of pedicellariae are present but are not usually distinctive.

Although reported from Zanzibar, Madagascar, and the Persian Gulf, the family is characteristic of the East Indies and Southeastern Japan. It is not represented in the Atlantic or Eastern Pacific Oceans. The grouping of the species in genera has been a source of no little difference of opinion among students of the family, owing to a belief that the number of genital pores is variable, some individuals having four and some five, even in the same species. After examining hundreds of specimens of at least twelve species, I feel satisfied that the number of genital pores is a very constant character and serves very well to distinguish two genera within the family.

Key to the Genera of Laganidae.

Genital pores 5 or 6, present in all interambulacra . . . . . *Laganum.*
Genital pores 4, wanting in posterior interambulacrum . . . . . *Peronella.*

Laganum.

Gray, 1825. Ann. Phil., **26**, p. 427. (*Lagana* by error).

Type, *Echinodiscus laganum* Leske, 1778. Add. ad Klein, p. 140.

In de Meijere's very careful and admirable revision of this genus (Siboga Ech., p. 113–131), no attempt is made to group the species in subgenera or to separate a genus Peronella, though there is a brief discussion of some of the points involved. In his key, de Meijere uses the *position* of the genital pores as a primary mark of distinction, between the species; while I do not question its importance, I am inclined to think the *number* is a more fundamental character. He further points out important characters in the position, form and covering of the periproct, to which earlier writers had paid small heed. His interesting discoveries in regard to the spines have already been discussed (p. 14). Of his four new species, I think two must be referred to the very variable *L. fudsiyama*, although further study on still more abundant material may show that I am quite wrong. For the present, I recognize six species of Laganum.

Key to the Species of Laganum.

Genital pores at proximal ends of interambulacra, more or less close to madreporite.
- Anus midway between margin and mouth, longitudinally elongated; test thick, with depressed petaloid area and swollen margins . . . . . *laganum.*
- Anus distinctly nearer to margin than to mouth, usually transversely elongated; test with petaloid area more or less elevated and margins not swollen.
  - Petaloid area relatively large, its total length .60 test-length or more; test with more or less pentagonal ambitus, its length usually decidedly greater than breadth . . . . . *depressum.*
  - Petaloid area relatively small, its total length .50 test-length or less; test with decagonal or rounded ambitus, its length little, or not at all, exceeding breadth.
    - Petals small but relatively broad, with curved poriferous areas, converging to the nearly or quite closed tip; test low, v. d. .13–.18 test-length . *decagonale.*
    - Petals narrow, poriferous areas little curved and tips widely open.
      - Test relatively high, v.d. ranging from .20 to .40 test-length; posterior interradius with one genital pore; tuberculation of test rather coarse (within a petal 10 mm. long there are about 20–25 primary tubercles and in one 15 mm. long, there are about 40–50) . . . . . *fudsiyama.*
      - Test lower, v.d. less than .20 test-length; two genital pores generally present in posterior interradius; tuberculation of test finer (within a petal 10 mm. long, there are 40–50 primary tubercles and in one 15 mm. long, there are 80–90) . . . . . *diploporum*

Genital pores in interambulacra, some distance from madreporite . . . . . *putnami*

Laganum laganum.

Echinodiscus laganum Leske, 1778. Add. ad Klein, p. 140.
Lagana laganum de Blainville, 1830. Dict. Sci. Nat., **60**, p. 196.

Plate 124, fig. *17*.

The tridentate pedicellariae of this species are rather characteristic and as they have never been figured, I have thought it desirable to show one valve (Pl. 124, fig. *17*). The geographical range of *L. laganum* is from the Philippine Islands, east to the Carolines, and southward to Tasmania.

Laganum depressum.

Agassiz, 1841. Mon. Scut., p. 110.

Plate 124, figs. *7–12*.

So far as I can judge from his description, the Laganum, which Mazzetti (1895, Mem. Reg. Accad. Sci. Modena, ser. 2, **10**, p. 217) described as new under the name *fragile*, is simply one of this species.

The pedicellariae are not very common but are rather characteristic. The ophicephalous have heads .30–.35 mm. long; the blade (Pl. 124, fig. *9*) has coarsely serrate margins; the loops differ very much on the three valves (Pl. 124, figs. *10–12*). The tridentate have slender, bent valves (Pl. 124, figs. *7*, *8*) about .40 mm. long. The miliary spines examined by me had square-cut tips, not sloping as figured by de Meijere, but this may be a matter of the place on the test, whence the spine is taken.

The Albatross brought home three bleached bare tests of this species, collected at Wotje, Marshall Islands, 22 January, 1900.

Laganum decagonale.

Scutella decagonalis de Blainville, 1827. Dict. Sci. Nat., **48**, p. 229.
Peronella decagonalis A. Agassiz, 1872. Rev. Ech., pt. 1, p. 148.
Laganum decagonale Bell, 1884. Alert Ech., p. 122.

The exact geographical range of this species is uncertain owing to its having been confused with others. Specimens are in the M. C. Z. collection from the Arafura Sea (Challenger coll.), the Philippine Islands, and "Durban, Natal." The last was purchased from a European dealer and the locality cannot be considered as unimpeachable, although there is no obvious reason for questioning it.

Laganum fudsiyama.

Döderlein, 1885. Arch. f. Naturg., **51**, 1, p. 104.

Plates 124, figs. *13–16;* 127, figs. *7*, *8;* 140, figs. *3*, *4;* 141, figs. *4–9*.

The large series of Laganum collected by the Albatross has proven a source of much interesting study, but no little perplexity, owing to the great diversity shown in the height of the test and in the number of genital pores. The conclusion was finally reached that the former is a very variable and unimportant character while the latter is a very constant and useful one. Dr. Döderlein has been so good as to send me authentic specimens of *fudsiyama* from Japan, so I have no doubt as to the authenticity of my Japanese specimens. These specimens range in length from 50 to 71 mm., while those from the Hawaiian Islands range from 8 to 50. The latter are as a rule much higher than the former but owing to the absence of small specimens from Japan, I cannot decide whether the height is a youthful character or not. So far as I can see de Meijere's *L. conicum* is identical with *fudsiyama* and apparently his *L.*

solidum is also; the Hawaiian specimens which Mr. Agassiz and I had referred to *solidum* are almost certainly *fudsiyama* but it is possible that de Meijere's East Indian specimens are identical with our species *diploporum*.

The color of *fudsiyama* is usually green (at least in alcoholic and dry specimens) but ranges from grayish yellow to rich, deep green. In the Hawaiian specimens, the ambulacra on the actinal side are often more or less colored with dark purplish brown, the contrast between ambulacra and interambulacra being frequently very marked (Pl. 141, fig. *9*). The miliary spines are as de Meijere has figured them for *conicum* except that those I examined had square-cut, and not sloping, tips; the rods (Pl. 124, fig. *14*) widen gradually and are coarsely serrate at tip. Pedicellariae common; ophicephalous like those of *depressum*, the head setting into a hollow at the top of the stalk (Pl. 124, fig. *13*). The tridentate pedicellariae are of two kinds; in one the valves (Pl. 124, fig. *15*) are only .20–.25 mm. long and have a broad rather flat blade; in the other, the valves (Pl. 124, fig. *16*) are .35–.45 mm. in length, curved as in *depressum*, and have a mesh-work in the blade. The tuberculation of the test is rather coarse, as is shown in figs. *7* and *8*, Pl. 127.

The large series of specimens examined came from the following ALBATROSS stations. Many of them are bare and waterworn and some are not certainly identifiable.

Station 3700. Off Seno Umi, Honshu, Japan. Bott. temp. ? 63 fms. Vol. m., s.

Station 3748. Off Suno Saki, Honshu, Japan. Bott. temp. ? 73–200 fms. Yl. s., rot. co.

Station 3811. Off Honolulu Light, Oahu, Hawaiian Islands. Bott. temp. 70.5°. 52–238 fms. Co. s., r.

Station 3814. Off Diamond Head, Oahu, H. I. Bott. temp. 46°. 42–284 fms. Co. s., sh., st.

Station 3838. Off Lae-o Ka Laau Light, Molokai, H. I. Bott. temp. 67°. 92–212 fms. Fne. gy. br. s.

Station 3859. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 60.5°–60.2°. 138–140 fms. Fne. s., m.

Station 3863. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 61°–60°. 127–154 fms. Brk. co., ers. g., r.

Station 3876. Off Lahaina Light, Maui, H. I. Bott. temp. 74°. 28–43 fms. S., g.

Station 3984. Off Nawiliwili Light, Kauai, H. I. Bott. temp. 47°. 164–237 fms. Fne. co. s.

Station 4079. Off Puniawa Point, Maui, H. I. Bott. temp. 60.8°. 143–178 fms. Gy. s., for.

Station 4080. Off Puniawa Point, Maui, H. I. Bott. temp. 56.4°. 178–202 fms. Gy. s., for.

Station 4081. Off Puniawa Point, Maui, H. I. Bott. temp. 51.7°. 202–220 fms. Gy. s., for.

Station 4099. Off Puniawa Point, Maui, H. I. Bott. temp. 60.7°. 152–153 fms. Fne. s., for., sh.

Station 4101. Off Mokuhooniki Islet, Pailolo Channel, H. I. Bott. temp. 59.7°. 122–143 fms. Co. s., sh., for.

Station 4115. Off Kahuku Point, Oahu, H. I. Bott. temp. 55.1°. 195–241 fms. Co. s., for.

Station 4122. Off Barber's Point Light, Oahu, H. I. Bott. temp. 64.6°. 192–352 fms. Crs. co. s., sh.

Station 4132. Off Hanamaulu, Kauai, H. I. Bott. temp. 46.8°. 257–312 fms. Fne. gy. s., m.

Station 4965. Between Kobe and Yokohama, Japan. Bott. temp. 49.4°. 191 fms. Dk. gr.-gy. s., sh.

Station 4966. Between Kobe and Yokohama, Japan. Bott. temp. 44.1°. 244–290 fms. Br. m., s., for.

Station 4967. Between Kobe and Yokohama, Japan. Bott. temp. 45.9°. 244–253 fms. Br. m., s., for.

Station 5091. Off Gulf of Tokyo, Japan. Bott. temp. 47.6°. 197 fms. Gn. m., crs. bk. s., p.

Bathymetrical range, 28–352 fms. Extremes of temperature, 74°–44.1°. Four hundred and sixty-six specimens.

Laganum diploporum.[1]

A. Agassiz and Clark, 1907. Bull. M. C. Z., **51**, p. 129.

Plates 127, figs. *9–12;* 142, figs. *2–4*.

So nearly related is this species to the preceding (*fudsiyama*) that a detailed description would be quite superfluous. Comparison of figs. *2–4*, Pl. 142, with those of *fudsiyama* (Pl. 141, figs. *4–7*) will make plainer than any words the

[1] Διπλός = double + πόρος = pore, in allusion to the two genital pores in the posterior interambulacrum.

difference between the two species in form; comparison of fig. *9*, Pl. 127, with fig. *7* of the same plate will reveal the difference in tuberculation; and comparison of figs. *10–12*, Pl. 127, with fig. 8 of the same plate, shows at once the curious difference in genital pores. As regards this latter character it will be noted that there is great individual diversity in the position of the posterior pair of pores with relation to each other. In typical cases, they are well separated (Pl. 127, fig. *12*), but they are often near together (fig. *11*) or even more or less merged (fig. *10*), and when they are merged into one it is often difficult, and may be impossible, to see that there are two. (Of course, it is not probable that two pores are ever merged; the probability is that in such apparent cases we have incompletely separated pores arising from a single one; *i. e.* the single pore is the primitive, the pair of pores, the derived condition). When the two pores are quite distinct, each has its own genital duct, several millimeters in length, but it is not easy to decide whether there are two distinct gonads; the appearance is more that of a single, much branched gonad with two separate ducts. The spines and pedicellariae of *diploporum* are not certainly distinguishable from those of *fudsiyama*. In coloration too, the two species are not unlike. The largest specimen of *diploporum* in the ALBATROSS collection is 50 mm. long. Specimens under 15 mm. are not certainly distinguishable from *fudsiyama* and most specimens under 20 mm. do not show *six* genital pores. All of the specimens are from Japan and were taken at the following places. Many are nearly or quite bare.

It is notable that *fudsiyama* was taken at only one of these stations.

Station 3707. Off Ose Zaki, Honshu, Japan. Bott. temp. ? 63–75 fms. Vol. s., a., g.

Station 3748. Off Suno Saki, Honshu, Japan. Bott. temp. ? 73–200 fms. Yl. s., rot. co.

Station 4885. Between Nagasaki and Kagoshima, Japan. Bott. temp. 62°. 53 fms. Dk. gy. s., brk. sh.

Station 4888. Between Nagasaki and Kagoshima, Japan. Bott. temp. 59.7°. 71 fms. Dk. gy. s., brk. sh.

Station 4893. Southwest of Goto Islands, Japan. Bott. temp. 55.9°. 95–106 fms. Gy. s., brk. sh., p.

Station 4895. Southwest of Goto Islands, Japan. Bott. temp. ? 95 fms. Gn. s., brk. sh., p.

Station 4902. Southwest of Goto Islands, Japan. Bott. temp. 52.9°. 139 fms. Gy. s., brk. sh.

Station 4904. Southwest of Goto Islands, Japan. Bott. temp. ? 107 fms. Fne. gy. s., brk. sh.

Station 4933. Off Kagoshima Gulf, Japan. Bott. temp. 56°. 152 fms. Rky.

Station 4934. Off Kagoshima Gulf, Japan. Bott. temp. 56°. 103–152 fms. Rky.

Station 4937. Off Kagoshima Gulf, Japan. Bott. temp. 64.8°. 58 fms. M., lava., p.

Station 5055. Suruga Gulf, Japan. Bott. temp. 56°. 124 fms. Gn. m., gy. s., brk. sh., p.

Station 5070. Suruga Gulf, Japan. Bott temp. 57.6°. 108 fms. M., s., brk. sh.

Station 5092. Off Gulf of Tokyo, Japan. Bott. temp. 56.3°. 70 fms. Crs. bk. s.

Bathymetrical range, 53–200 fms. Extremes of temperature, 64.8°–52.9°.

Fifty-nine specimens.

Laganum putnami.

A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 359.

Plate 142, figs. *14–16*.

Although Mr. Agassiz, in his account of this species in the Revision, refers to "figures," I can not find that any figures have ever been published. I have therefore given photographs of one of the original specimens. The species seems to be a rare one for I do not find any records in print since 1863. Döderlein failed to find *putnami* in his collecting and the Albatross took no specimens in either of her voyages. The original specimens are hardly more than bare tests and no pedicellariae were seen.

Peronella.

Gray, 1855. Cat. Recent Ech., pt. 1, p. 13.

Type, *Laganum peronii* Agassiz, 1841. Mon. Scut., p. 123.

It is interesting to find that among these Laganidae having only *four* genital pores, there is, just as in the group having five or six such pores, one species in which these pores are far removed from the apical system. In fact Gray based his subgenus Peronella on the peculiar position of the pores, although he

lays equal stress on their number. Aside from the position of the genital pores, the position of the periproct and the size and form of the petals seem to be the most important specific characters. Whether the plates which cover the periproct carry spines (miliaries) or not is also a character of some importance, and the form of the test and the thickness of its margins are also of value. In the Revision, Mr. Agassiz gives four species of Peronella but one of these (*rostrata*) seems to be identical with *orbicularis*, as Mr. Agassiz himself suggests is probable. Since the publication of the Revision, Pfeffer, Döderlein, and de Meijere have added species to the genus. Of Pfeffer's three "new" forms, *pallida* can hardly be considered a separate variety of *lesueuri*, as that species varies considerably in color; *ludwigii* is so near *orbicularis* I find no way of separating them; and *elegans* seems to be a young example of the same species. The record of *ludwigii* from St. Thomé must certainly be due to an erroneous label, for none of the family occur in the Atlantic ocean. Döderlein's two Japanese species seem to be perfectly valid and the same is apparently true of de Meijere's two from the East Indies. The species Mr. Agassiz and I described in 1907 as *Laganum strigatum* was based primarily on a specimen which proves to be a Peronella and I have therefore transferred that species to this genus. It will thus be seen that I find it desirable to recognize eight species of Peronella.

Key to the Species of Peronella.

Genital pores at proximal ends of interambulacra more or less close to madreporite.

Anus (*i. e.* center of periproct) .15–.30 of long radius from margin.

Petaloid area only about .40 test-length; petals narrow, open; poriferous areas nearly parallel; anal plates without spines; test flat with thin margin (about .06 test-length) . . . . . *strigata.*

Petoloid area half test-length, or more; petals variable in form but rather broad, sometimes open, especially unpaired one, but usually more or less closed and pointed.

Margin of test thick, about .12 test-length; petaloid area, about .60 test-length . . . . . *orbicularis.*

Margin of test thin, about .07 test-length; petaloid area about .50 test-length. *lesueuri.*

Anus .40–.50 of long radius from margin.

Height of test rather less than .20 of length.

Petaloid area rather less than half test-length; margin of test very thin, about .06 test-length; anal plates without spines; test about as wide as long. *pellucida.*

Petaloid area more than half test-length; margin of test about .09 test-length; anal plates with spines.

Test about nine tenths as wide as long or wider; petals open; poriferous areas little curved . . . . . *rubra.*

Test about four fifths as wide as long; petals closed; poriferous areas curved, converging at tip . . . . . *minuta.*

Height of test rather more than .25 of length; periproct very large, longitudinally elongated; anal plates without spines; petals very broad, short, pointed . . . *analis.*
Genital pores in interambulacra at a greater or less distance from madreporite . . . . . *peronii.*

Peronella strigata,[1] comb. nov.

Laganum strigatum A. Agassiz and Clark, 1907. Bull. M. C. Z., **50**, p. 250.

Plate 142, figs. *11–13.*

Length, 30 mm.; breadth, 29 mm.; height, 6 mm.; margins about 1.8 mm. thick; petaloid area, 12 mm. long; petals about equal, 1.7 mm. wide, open by nearly a millimeter, as poriferous areas (12–14 pore-pairs on each side) are nearly parallel. Mouth central. Periproct, 2.5 mm. long by 2 mm. wide, situated 3 mm. from margin, covered with plates which do not carry spines. Genital pores four the posterior interambulacrum having none. Tuberculation of test moderate, including many glassy tubercles of about the same size and abundance as the primary tubercles. Sutures between plates sharp and well defined. Miliary spines with the component rods gradually widened and rather finely serrate at tip. Pedicellariae not peculiar or distinctive in any way; no triphyllous were found and tridentate and ophicephalous are not common. Color light brown with the sutures darker and more or less purple.

The holotype and only specimen is from ALBATROSS

Station 3859. Off Mokuhooniki Islet, Pailolo Channel, Hawaiian Islands. Bott. temp. 60.5°–60.2°. 138–140 fms. Fne. s., m.

In the original description of this species, specimens of *Laganum fudsiyama* were included and are referred to as having *five* pores. The species are undoubtedly nearly allied but aside from the difference in number of genital pores and in color, there is a difference in the form of the periproct, which is not elongated in *fudsiyama.*

Peronella orbicularis.

Echinodiscus orbicularis Leske, 1778. Add. ad. Klein, p. 144.
Peronella orbicularis A. Agassiz, 1872. Rev. Ech. pt. I, p. 149.

Specimens of this species are in the M. C. Z. collection from the Persian Gulf, Philippine Islands, and Torres Strait. My observations accord with de Meijere's, except that I failed to find the tridentate pedicellariae which he figures.

[1] *Strigatus* = furrowed, in reference to the very distinct sutures between the plates.

Peronella lesueuri.

Laganum lesueuri Agassiz, 1841. Mon. Scut., p. 116.
Peronela lesueuri A. Agassiz, 1872. Rev. Ech., pt. 1, p. 148.

Plate 124, figs. *23*, *24*.

The component rods of the miliary spines do not seem quite so abruptly widened as de Meijere figures them. The triphyllous pedicellariae are fairly common and have very abruptly expanded valves (Pl. 124, fig. *23*). I failed to find (in four specimens) any ophicephalous. The tridentate are very variable, having valves ranging in length from .10 to .45 mm. One form has the valves curved in such a way (Pl. 124, fig. *24*) as to resemble "globiferous" pedicellariae and these are the most characteristic of all. This species reaches the largest size of any of the Laganidae and specimens exceeding 130 mm. in length are not rare. There are specimens in the M. C. Z. collection from Japan, Hong Kong, Singapore, Philippines, Dutch East Indies, and Queensland.

Peronella pellucida.

Peronella (Laganum) pellucida Döderlein, 1885. Arch. f. Naturg. **51**, 1, p. 104.

Plate 142, figs. *1*, *8–10*.

Döderlein gives 32 mm. as the diameter of his largest specimen, but one in the M. C. Z. collection (Pl. 142, fig. 1) is 50 mm. across. In large specimens, the test is not nearly so thin and transparent as in younger specimens although it is not as thick-walled as in related species. The miliary spines have their component rods very abruptly expanded at the tip; the margin of this expanded part is usually entire, but may be finely or coarsely serrate. All three kinds of pedicellariae are present, but they are very small; the largest tridentate have valves only .10–.12 mm. The valves of the triphyllous have coarsely dentate margins, as in *rubra* (Pl. 124, fig. *20*) but the "teeth" are longer.

The Albatross took *pellucida* twice during its trip to Japan in 1900 and once during its much more extended visit in 1906. The specimens range from 20 to 45 mm. in length.

Station 3708. Off Ose Zaki, Honshu, Japan. Bott. temp. ? 60–70 fms. Gn. m., vol. s., a.

Station 3713. Off Ose Zaki, Honshu, Japan. Bott. temp. ? 45–48. fms. Vol. s., sh., r.

Station 4885. Between Nagasaki and Kagoshima, Japan. Bott. temp. 61.7°. 53 fms. Dk. gy. s., brk. sh.

Bathymetrical range, 45–70 fms.

Twelve specimens.

Peronella rubra.

Peronella (Laganum) rubra Döderlein, 1885. Arch. f. Naturg., **51**, 1, p. 106.

Plates 124, figs. *18–20;* 142, figs. *5–7*.

The miliary spines are like those of *pellucida;* the component rods (Pl. 124, figs. *18*, *19*) being abruptly expanded at the tip. The pedicellariae are all small and are best designated as triphyllous; the blades are coarsely dentate (Pl. 124, fig. 20) and are only .04–.08 mm. long. No tridentate or ophicephalous pedicellariae could be found. The ALBATROSS did not take this species. The specimens figured are in the M. C. Z. collection.

Peronella minuta, comb. nov.

Laganum minutum de Meijere, 1904. SIBOGA Ech., p. 125.

I have not seen this species which is known only from the Sulu Archipelago.

Peronella analis, comb. nov.

Laganum anale de Meijere, 1904. SIBOGA Ech., p. 129.

Having one of the SIBOGA specimens at hand, I can confirm de Meijere's observations. I also found triphyllous pedicellariae. This species was taken by the Siboga at three widely separated stations in the Dutch East Indies.

Peronella peronii.

Laganum peronii Agassiz, 1841. Mon. Scut., p. 123.
Laganum (Peronella) peronii Gray, 1855. Cat. Rec. Ech. Irreg., p. 13.

Plate 124, figs. *21*, *22*.

As this is the type of the genus and was not studied by de Meijere, a few notes may be given here. The component rods of the miliary spines are abruptly expanded and the terminal margin is rather finely serrate. Aside from some ophicephalous pedicellariae, the valves of which have broad and very blunt

blades (Pl. 124, fig. *21*), the only ones found may be called either small tridentate or triphyllous. Their valves (Pl. 124, fig. *22*) have the blades very broad and the margins very coarsely dentate. As these valves are scarcely .10 mm. in length, I have preferred to call them triphyllous. Australia and Tasmania are the home of this interesting species.

FIBULARIIDAE Gray.

It is of course difficult to determine whether the simple nature of the petals and madreporite in the members of this family are primitive characters retained or secondary simplifications. From the geological point of view, this group ought to be the ancestral stock from which the other clypeastroids have been derived, it is known from so much earlier strata than any of the others. But if we disregard this single fact, it becomes evident that nothing in the structure of the Fibulariidae requires us to consider them as primitive, while many details suggest that they are highly specialized. Thus there can be no question that the condition of the auricles and the arrangement of the aboral interambulacral plates are both specialized, and it seems equally clear that the structure of the miliary spines is of the same nature. These three characteristic features ally the family very closely with the Laganidae, while the two characters which separate the two families, the condition of the petals and madreporite, cannot be positively placed as either primitive or derived. Hawkins (1912, Geol. Mag., new ser. dec. 5, 9, p. 297) has recently described a Fibularia from southern Nigeria, which is very interesting in considering this matter, for it has well-differentiated petals and numerous madreporic pores. Unfortunately Mr. Hawkins has not been able to determine the condition of the auricles. The geological horizon of this species is "probably Lower or Middle Eocene." It is possible to interpret this as one of the early, primitive species of the family from which our modern Fibulariidae have been derived by the reduction of the petals and loss of all madreporic pores but one. Except for the shape of the test and the unusually divergent poriferous areas, *Fibularia nigeriae* is just as much one of the Laganidae as it is one of the Fibulariidae. It seems therefore that the discovery of *F. nigeriae* strengthens the belief that the Fibulariidae are a modern, highly specialized family nearly related to the Laganidae, and probably derived from the same stock.

The family contains only two genera and these are not to be distinguished

from each other by any external characters. Yet the internal structure of the test is so different in the two genera and this difference is so constant, that I have been forced to adopt as the distinguishing character the presence or absence of internal radiating partitions. Comparison of figures *3* and *7* on Plate 126 will make this difference more clear than an elaborate description. The partitions in Echinocyamus do not always extend the whole length of the radius but may run inward only a short distance from the margin (Pl. 127, fig. *3*). In Fibularia, however, there is generally no indication of such partitions except in the posterior part of the test. Externally the two genera are strikingly similar, especially when covered with their spines, but as a rule the species of Echinocyamus are flat and broad while in Fibularia, the vertical diameter is usually more considerable. Echinocyamus is world-wide in its distribution although it is not yet known from the west coast of America, but Fibularia is confined chiefly to the East Indian region, ranging from Japan to Australia; specimens are also known however from the Red Sea.

Key to the Genera of Fibulariidae.

Test more or less elevated, without internal radiating walls, except posteriorly where they are usually indicated . . . . . *Fibularia.*

Test more or less flattened with internal radiating walls bounding the ambulacra . . *Echinocyamus*

Fibularia.

Lamarck, 1816. Anim. sans Vert., **3**, p. 16.

Type, *Fibularia trigona* Lamarck, *loc. cit.* = *Echinocyamus craniolaris* Leske, 1778. Add. ad Klein, p. 150.

The species of this genus are known almost wholly from the bare tests. Excepting the Australian species *nutriens*, I have seen no specimens clothed in spines. The Siboga collected three species in the Dutch East Indies, but apparently of only one were there specimens with spines and pedicellariae. Our knowledge of these external structures is therefore quite deficient but enough is known to satisfy us that in neither spines nor pedicellariae does the genus differ essentially from Echinocyamus. The Albatross has not collected any examples of Fibularia, the specimens from the Hawaiian Islands referred to *F. australis* in the preliminary report (Bull. M. C. Z., **50**, p. 247) proving to be Echinocyamus. More than twenty-five species of Fibularia have been named but the great majority of them were based on specimens of Echinocyamus, on young clypeastroids of other genera, or on individual variants of *F. craniolaris*. All told there seem to be six valid species in the genus, so far as present knowledge

goes. Possibly even this is too large a number, for there is no doubt of the great variability in form shown by *craniolaris* and *volva* and very likely there is equal variability in the development of the petals and the size of the pores. Moreover material is scanty and further accumulations may prove the basis for very different conclusions.

Key to the Species of Fibularia.

Petals present, more or less well formed; no obvious sexual dimorphism.
- Pores of petals small, usually much smaller than genital pores.
  - Anus large nearly or quite equalling mouth; test flattened, v.d. about .40 test length; petals well developed with 8–24 pore-pairs on each side . . . . . *australis.*
  - Anus very small, not half as large as mouth.
    - Test high (v.d. often .80 test-length), broad (.80–.90 t.–l.), more or less egg-shaped . . . . . *craniolaris.*
    - Test low (v.d. about .40 t.–l.) and not very broad (about .80 t. l.) . . . . *acuta*
- Pores of petals few and large, usually bigger than genital pores; anus scarcely half as large as mouth or even smaller.
  - Petals rather short but with from 40 to 120 pores in all five together; test about half as high as long . . . . . *volva.*
  - Petals ill defined, covering most of abactinal surface, with only 30–36 large pores; test about two fifths as high as long . . . . . *cribellum.*

Petals wanting; dorsal surface of female with conspicuous depressed brood-pouch . . . *nutriens.*

Fibularia australis.

Desmoulins, 1837. Études sur les Ech. Tab. Syn., p. 240.

This is the largest species of the family, reaching a length of nearly 20 mm. There are specimens in the M. C. Z. collection from the Hawaiian, Gilbert, and Kermadec Islands, but these are all small. The large specimen, figured in the Revision, was purchased in Hamburg and the original locality is not known.

Fibularia craniolaris.

Echinocyamus craniolaris Leske, 1778. Add. ad Klein, p. 150.

Fibularia craniolaris de Blainville (not de France, as stated in the Revision, p. 129), 1820. Dict. Sci. Nat., **16**, p. 512.

Echinus ovulum Gmelin, 1788. Linné. Syst. Nat., ed. 13, p. 3194. (*Fibularia ovulum* Lamarck, Agassiz, Gray, A. Agassiz, *et al.*).

I have not been able to find any good reason why *ovulum* should take precedence over *craniolaris* as the correct name for this species, as the latter was used in connection with a description and figure, which are as recognizable as could be expected at that date, ten years earlier.

Fibularia acuta.

Yoshiwara, 1898. Ann. Zool. Japon., **2**, p. 60.

Plate 126, figs. *1–4*.

Through the great courtesy of Dr. Goto in sending me one of Yoshiwara's type specimens, I am able to supplement his description with figures. There seems to be no doubt of the distinctness of this species, for the shape of the test is quite unlike that of any of the numerous forms of *craniolaris*. The specimen figured was taken at Asamiwan, Tsu-shima, in Korea Strait.

Fibularia volva.

Agassiz and Desor, 1847. Ann. Sci. Nat., ser. 3, **7**, p. 142.

This species has the widest known range of any member of the genus. There are specimens in the M. C. Z. collection from the Red Sea, Japan, the Kei Islands, and Torres Strait.

Fibularia cribellum.

De Meijere, 1903. Tijdschr. Nederland Dierk. Ver., ser. 2, **8**, p. 7.

The SIBOGA took six specimens of this species at six very widely separated points in the Dutch East Indies, but apparently they were all bare tests for de Meijere makes no reference to either spines or pedicellariae.

Fibularia nutriens.

H. L. Clark, 1909. Mem. Austr. Mus., **4**, p. 557.

This, the smallest known species of echinoid, has been recorded only from the coast of New South Wales. In the original description I recorded it as the only clypeastroid known in which the test of the female was modified for the purpose of caring for the young. Dr. F. A. Bather promptly called my attention to a paper by Dr. T. S. Hall On the occurrence of a marsupium in an echinoid belonging to the genus Scutellina, (1908, Proc. Roy. Soc. Victoria, new ser., **20**, p. 140–142). The marsupium in Scutellina is on the oral surface anterior to the mouth and hence very different from the one in *F. nutriens*.

Echinocyamus.

Leske, 1778. Add. ad Klein, p. 149.

Type, *Echinocyamus angulosus* Leske, *op. cit.*, p. 151 = *Echinus minutus* Pallas, 1774. Spic. Zool., 10, p. 34, pl. 1, fig. 25.

Although Mr. Agassiz, in the Revision, only recognized one species in this genus, the later work of Mazetti, de Meijere, and Mortensen has shown that the genus really contains a considerable group of more or less distinct species. In studying the large series of specimens in the M. C. Z. collections, I discovered two very distinct, undescribed species, and careful examination of the Hawaiian Fibulariidae collected by the Albatross has forced me to the conclusion that that small series includes two new forms. I therefore recognize at the present time eleven species, but admit freely that three or four of these are difficult to differentiate clearly and possibly are not valid. I have examined specimens of nine species but have not seen either *elegans* or *macrostomus;* the latter seems to be perfectly distinct, but *elegans* is dubious to say the least. All of the species are small, specimens exceeding 10 mm. in length being quite unusual although Mortensen records one 15 mm. long. The bathymetrical range of the species is nearly as remarkable as their wide geographical distribution for while they are chiefly confined to shallow water, at least one species occurs at from 800–1,270 fms.

Key to the Species of Echinocyamus.

Petals well formed with six or more pore-pairs on each side.
- Poriferous areas slightly curved and converging, at least in posterior pair of petals; test closely covered with minute tubercles; primaries scattered and smaller than genital pores; test not concave orally but a little depressed back of mouth; ocular pores smaller than genital . . . . . *provectus.*
- Poriferous areas straight, parallel on diverging; test covered with coarser tubercles; primaries larger than genital pores.
  - Petals very conspicuous reaching nearly to margin (except posteriorly); poriferous areas widely divergent with ten to fifteen pore-pairs in each; periproct nearer mouth than margin; test rather high, flat above, somewhat concave beneath; mouth longer than wide . . . . . *megapetalus.*
  - Petals less conspicuous; poriferous areas parallel or slightly diverging, usually with fewer than ten pore-pairs in each.
    - Test flattened; apical system anterior to center.
      - Test wide, its breadth rarely less than .80 of length; flat or slightly concave orally . . . . . *minutus.*
      - Test long and narrow, its breadth only about .70 of length; markedly concave orally, at least posterior to mouth . . . . . *elongatus*

Test more or less arched above; apical system at center; markedly concave below; mouth pentagonal.
Poriferous areas slightly depressed with intervening parts of test usually elevated; interambulacra often form more or less evident keel-like ridges proximally; pore-pairs in specimen about 7 mm. long, six to seven on each side . . . . . *crispus.*
Poriferous areas flush with surface of evenly arched test; pore-pairs more numerous, about nine on each side of petal in specimen 5.5 mm. long . . . . . *elegans.*
Petals more or less imperfect with one to five (rarely six) pore-pairs on each side.
Glassy tubercles of test conspicuously high, numerous, rounded or bluntly pointed, making surface of test very rough; test broad and flat; ocular pores smaller than genitals, though the difference may be very slight . . . . . *scaber.*
Glassy tubercles low, rounded and often few in number.
Ocular pores nearly or quite as big as genitals . . . . . *grandiporus.*
Ocular pores much smaller than genitals.
Test exceedingly flat, v. d. less (often much less) than .25 of test-length; periproct near margin, distant from mouth twice its own diameter or more . . . . . *platytatus.*
Test not so flat; periproct more or less nearly midway between mouth and margin.
Unpaired petal with about four pore-pairs on each side; diameter of mouth about twice that of periproct . . . . . *incertus.*
Unpaired petal with only one or two pore-pairs on each side; diameter of mouth about three times that of periproct . . . . . *macrostomus.*

Echinocyamus provectus.

De Meijere, 1903. Tijdschr. Nederland Dierk. Ver. ser. 2, **8**, p. 6.

This species is known from four stations in the Dutch East Indies, in 50–200 fms. and from the coast of New South Wales in 40–60 fms.

Echinocyamus megapetalus,[1] sp. nov.

Plate 126, figs. *5–8.*

Length, 7 mm.; breadth, 5 mm.; height, 2.8 mm.; mouth, 1.5 × 1 mm.; periproct not quite 1 mm. in diameter. Test high, but flattened aborally and somewhat concave beneath. Apical system at center. Petals very distinct and large; poriferous areas widely divergent, each with ten to fifteen pairs of pores. Periproct nearer to mouth than to margin. Genital pores larger than ocular pores. Radiating partitions within test very well developed (Pl. 126, fig. 7). Auricles conspicuous in interambulacra. Ambulacra more than

[1] μέγας = big + πέταλον = petal, in allusion to the unusual size of the petals.

twice as wide as interambulacra at ambitus. Primary tubercles relatively large, evidently larger than genital pores. Glassy tubercles rounded and inconspicuous. Madreporic pore smaller than a genital pore.

The holotype and five other specimens in the M. C. Z. collection are all from Mauritius. They are bare tests, received from Mrs. Luckock some forty years ago.

This is certainly the most distinct and easily recognized member of the family, and is not especially near any of the other species of Echinocyamus, the large and rather ornamental petals being quite distinctive. All of the specimens are white and have the appearance of being slightly water worn.

Echinocyamus minutus.

Echinus minutus Pallas, 1774. Spic. Zool., **10**, p. 34.
Echinocyamus minutus de Blainville, 1834. Man. Act., p. 214.

When Pallas's description of his *Echinus minutus* is carefully examined in connection with his fig. 25, pl. 1, and due consideration is given to his remarks about habitat and occurrence, it is almost impossible to doubt that his name was given to the fibulariid which O. F. Müller two years later called *Spatagus pusillus*. Although *Echinocyamus pusillus* is the name used in the Revision and other later publications, I am therefore obliged to replace it with *Echinocyamus minutus* (Pallas).

Echinocyamus elongatus,[1] sp. nov.

Plate 126, figs. *9–11*.

Length, 9 mm.; breadth, 6 mm.; height, 2.6 mm.; mouth about 1.5 mm. across and periproct about .8 mm. Test long, low, flat and rather narrow for a fibulariid. Apical system decidedly anterior to center. Mouth somewhat sunken and test posterior to it decidedly concave. Petals distinct and well formed but rather short. Poriferous areas nearly parallel, each with about ten pairs of pores. Periproct about midway between mouth and margin. Genital pores larger than ocular pores. Radiating partitions within test fairly well developed. Auricles rather low, but wide. Ambulacra scarcely twice as wide as interambulacra at ambitus. Horizontal series of ambulacral pores distal to petals, conspicuous. Primary tubercles large, larger than genital pores.

[1] *elongatus* = lengthened, in reference to the form of the test.

Glassy tubercles insignificant. Madreporic pore smaller than a genital pore. Color of bare test, pale brown.

The holotype is from Station 3846.

Although rather closely allied to *E. minutus* of Europe, this species is easily distinguished by its narrow test. Several of the specimens from Hawaii, which I refer to this species, are very young. One of these, a bare test, shows considerable resemblance to *E. megapetalus*, as the apical system is nearly central. Two other specimens are clothed in their natural coat of spines; the color is pale yellowish brown; the primaries are about twice as long as the miliaries and neither are peculiar; no pedicellariae were found. There are two bare tests of this species, from Guam, in the M. C. Z. collection.

The Hawaiian specimens were taken at the following places:—

Station 3846. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 71.5°. 60–64 fms. Crs. br. s, sh., gr.

Station 4064. Off Kauhola Light, Hawaii, H. I. Bott. temp. 69°. 63–107 fms. Vol. s., for., co.

Station 4148. Off Modu Manu, H. I. Bott. temp. 77.9°. 26–33 fms. Co. s., for.

Bathymetrical range, 26–107 fms. Extremes of temperature, 77.9°–69°. Six specimens.

Echinocyamus crispus.

Mazetti, 1895. Mem. Reg. Accad. Sci. Modena, ser. 2, **10**, p. 215.

Although originally described from the Red Sea, this species seems to be common in the East Indies, where the Siboga took it at many stations.

Echinocyamus elegans.

Mazetti, 1895. Mem. Reg. Accad. Sci. Modena, ser. 2, **10**, p. 216.

This is another Red Sea species, but it has not yet been taken elsewhere and its validity as a good species is open to considerable question.

Echinocyamus scaber.

De Meijere, 1903. Tijdsch. Nederland Dierk. Ver., ser. 2, **8**, p. 5.

I have nothing to add to de Meijere's full account of this species given in his report on the Siboga Echini (1904). The Hawaiian specimens agree very

well with his description and figures. The depth at which this species lives is worthy of remark. The Albatross specimens were taken at the following places:—

Station 3839. Off Lae-o Ka Laau Light, Molokai, Hawaiian Islands. Bott. temp. 46.3°. 259–266 fms. Lt. br. m., s.

Station 3908. Off Diamond Head, Oahu, H. I. Bott. temp. 43.8°. 304–308 fms. Fne. wh. s., m.

Station 3914. Off Diamond Head, Oahu, H. I. Bott. temp. 46° (?). 289–292 fms. Gy. s., m.

Bathymetrical range 259–308 fms. Extremes of temperature, 46.3°–43.8°.

Five specimens, of which four are bare tests.

Echinocyamus grandiporus.

Mortensen, 1907. Ingolf Ech., pt. 2, p. 33.

Dr. Mortensen's presentation of the claims of this species is quite convincing. There are specimens in the M. C. Z. from numerous stations in the West Indian region, extending from the Florida Keys, western Cuba, and Yucatan Bank, through the Leeward Islands and southward to Bahia, Brazil. The bathymetrical range is from 79 to 805 fms. There are no specimens of any other fibulariid from the West Indian region in the M. C. Z. collection.

Echinocyamus platytatus,[1] sp. nov.

Plate 127, figs. *1–6*.

Length 6 mm.; breadth, 5.5 mm.; height 1.4 mm., mouth about 1 mm., and periproct .6 mm., across. Test very low, broad and flat, not concave orally. Petals imperfect and indistinct with only two or three pairs of pores on each side. Periproct about twice as far from mouth as from margin. Sexes easily distinguishable, as the genital pores of the female (Pl. 127, fig. *6*) are very much larger than those of the male (Pl. 127, fig. *5*). Even in the male the genital pores are larger than the ocular pores. Radiating partitions in test not well developed (Pl. 127, fig. 3), extending scarcely half way from margin to mouth. Auricles low and wide. Ambulacra hardly twice as wide as interambulacra, at ambitus. Primary tubercles relatively large, but not so large as female

[1] πλατύτατος = most flat.

genital pores. Glassy tubercles low and inconspicuous. Madreporic pore small, not as large as male genital pore.

The holotype and numerous other specimens in the M. C. Z. collection are from Port Phillip, Victoria. All are bare tests and most of them are more or less water worn.

To the kindness of my friend, Dr. T. S. Hall of Melbourne, I owe the privilege of describing this interesting new species. Several years ago he sent specimens for identification, and when informed that they seemed to represent a new species which he ought to describe, he generously sent many more specimens with the statement that he wished me to do the describing. There is no doubt that *platytatus* is quite distinct from any previously known species, and the sexual dimorphism which it shows is most interesting, especially since it is an Australian species of Fibularia which shows the only sexual dimorphism known in that genus. The specimens of *platytatus* before me range from 2.7 mm. to 8 mm. in length; the largest is 7 mm. wide and 1.8 mm. high.

Echinocyamus incertus,[1] sp. nov.

Plate 128, figs. *1–3*.

Length 6 mm.; breadth not quite 5 mm.; height not quite 2 mm., mouth about 1.2 mm. in diameter and periproct about .6 mm. Test moderately flattened, narrowed anteriorly, not at all concave beneath, though there is a very slight depression just back of the mouth. Petals evident but poorly formed and with few pore-pairs, yet anterior petal has about four pore-pairs on each side. Periproct much nearer to margin than to mouth. Genital pores much larger than oculars. Radiating partitions within test (so far as can be seen through mouth) fairly well developed. Auricles rather low and broad. Primary tubercles about equal to genital pores. Glassy tubercles apparently wanting. Madreporic pore much smaller than a genital pore.

The holotype and only specimen is from Albatross Station 4045. Off Kawaihae Light, Hawaii, Hawaiian Islands. Bott. temp., 49°. 147–198 fms. Co. s., for.

In the preliminary report on the Albatross Hawaiian Echini (1907, Bull. M. C. Z., **50**, p. 247) this specimen was listed as "*Fibularia australis*," but as more detailed study has shown that there are no Fibularias in the collection, the proper identification of this specimen has given some trouble. I have finally

[1] *incertus* = dubious, in allusion to its doubtful status.

determined to name it as a new species of Echinocyamus. It is obviously different from the two other Hawaiian species collected by the Albatross, but how much of this difference is due to individual diversity, I cannot decide. It is hard to believe, however, that an individual variant of either *elongatus* or *scaber* would show the characters of this specimen.

Echinocyamus macrostomus.

Mortensen, 1907. Ingolf Ech., pt. 2, p. 36.

This Atlantic species is notable for its living at great depths. It is known only from stations in 800–1,270 fathoms.

SCUTELLIDAE Agassiz.

The form of the test and the condition of the auricles in the various members of this family indicate that it is a highly specialized group and this opinion is confirmed by the pedicellariae, which are rarely abundant, but are often very few in number and usually have only two valves. Nothing is known of the pedicellariae of Rotula and I regret to say no specimens of the genus, except bare tests, are in the M. C. Z. collection. Judging from the characters of the test alone, Rotula may well be considered the most highly specialized form of clypeastroid known either living or fossil. On the other hand, all the characters of Echinarachnius point to it as one of the least specialized members of the family and it is very possibly quite near the ancestral stock from which the scutellids arose. The recent genera of the family are easily distinguished from each other by very obvious external characters, the presence or absence of lunules and marginal slits being the most important. When lunules are present, their position and number furnish good, constant characters, but the size is often very variable, especially in Encope. The latter genus is further remarkable for being the only genus in the family which has retained five genital pores. The position of the periproct and of the apical system may be useful characters, and for specific differences the lengths of the different petals in relation to each other is often very important. The following key will serve to distinguish seven genera of recent scutellids.

Key to the Genera of Scutellidae.

Test without marginal slits or lunules.

Abactinal system at apex of test; petals about equal; periproct marginal . . . *Echinarachnius.*

Abactinal system posterior to apex; posterior petals much shorter than others; periproct on oral surface . . . . . *Dendraster.*

Test with marginal slits, or lunules, or both.
Not more than two marginal slits, and often none, in posterior half of test-margin.
No lunule in posterior interambulacrum.
Two lunules or marginal slits present, one in each posterior ambulacrum *Echinodiscus.*

Five lunules present, one in each ambulacrum . . . . . *Astriclypeus.*
A lunule in posterior interambulacrum.
Genital pores 5 . . . . . *Encope.*
Genital pores 4 . . . . . *Mellita.*
Eight or more marginal slits in posterior half of test-margin . . . . . *Rotula.*

Echinarachnius.

Gray, 1825. Ann. Phil., 26, p. 428.

Type, *Scutella parma* Lamarck, 1816. Anim. sans Vert., 3, p. 11.

Although this genus is easily recognized, specific limits within it are very perplexing and have been the source of some confusion and probably of no little error with reference to the geographical distribution of the different forms. The Northern Pacific Ocean, particularly the vicinity of Kamtchatka and Japan seem to be the center of distribution for the genus. All three of the species here recognized as valid occur there and two of them are not known from elsewhere. The extraordinary range ordinarily attributed to *E. parma* requires a reinvestigation. The records from the Red Sea, Mauritius, Indian Ocean, and Australia are almost certainly erroneous and there is no reason to believe that the genus occurs south of 32° N. in either the Atlantic or Pacific Oceans. The only characters which are available for distinguishing species are the shape of the petals, the height and solidity of the test, the manner of branching of the actinal ambulacral furrows, and the color. The last may be a very constant and valuable character for all we know to the contrary but unfortunately the red-brown pigment of clypeastroids (or at least of many of them) becomes transformed into a beautiful green color on immersion in fresh water or alcohol, and even undergoes more or less change in drying. Museum specimens of Echinarachnius may thus show an extraordinary diversity of color, no shades of which are necessarily distinctive. The use of color therefore as a specific mark is open to serious objection, yet in some cases it is certainly helpful. The shape of the petals and of the test are hardly less uncertain characters than the color and too much stress must not be laid on any one character. The forking of the actinal ambulacral furrows is of course a much more fundamental character than any of the others, and differences shown in this feature seem to be very

constant. The pedicellariae are reduced in both number and size. All have two valves. The bidentate are remarkable for the more or less complete lack of apophyses, while the biphyllous are very small indeed and of rather an odd shape (Pl. 125, fig. 7). There are no calcareous disks or rings in the pedicels but each sucker is strengthened by a pair of calcareous rods, somewhat bent, lying with their concave sides towards each other and with an outstanding spine on the convex side. After the examination of hundreds of specimens, it has seemed desirable to recognize three species and one variety.

Key to the Species of Echinarachnius.

Actinal ambulacral furrows branching only near distal end.
- Test variable in height but not remarkably thick and solid; color in life reddish brown of some shade, often very light, becoming green in alcohol and drying green or brown often very dark; abactinal primary spines not conspicuously thickened near tip.
  - Test low and flat, v. d. .11–.18 test-length . . . . . *parma.*
  - Test high, sometimes more or less conical, v. d., .17–.25 test-length . . . *parma* var. *obesa.*
- Test high, v. d. = .18–.25 test-length, and remarkably thick and solid; color in life unknown; alcoholic and dry specimens similar, more or less strongly violet, especially on oral surface, but primary spines whitish; abactinal primary spines remarkably swollen near tip . . . . . *asiaticus.*

Actinal ambulacral furrows forking proximal to middle . . . . . *mirabilis.*

Echinarachnius parma.

Scutella parma Lamarck, 1816. Anim. sans Vert., 3, p. 11.
Echinarachnius parma Gray, 1825. Ann. Phil., **26**, p. 428.

Plate 125, figs. *7*, *8*.

This is the common sand-dollar of the East coast of North America, from New Jersey northward at least to Labrador. Apparently it occurs on the West coast also from Alaska as far south as Puget Sound. On the Asiatic coast it is represented by the following variety, which also occurs along the Alaskan Peninsula.

Echinarachnius parma var. obesa,[1] var. nov.

Plate 143, figs. *5–8*.

Similar to *E. parma* except that the test is remarkably high, the vertical diameter often one fourth of the test-length. Extreme examples are so unlike the ordinary *parma*, one is tempted to consider them a distinct species and Mr.

[1] *obesus* = fat, in allusion to the plump test.

Agassiz (1872, Rev. Ech., p. 108, 316, 317) supposed that it was such a specimen on which Michelin founded his species *asiaticus*. Consequently Mr. Agassiz considered *asiaticus* a synonym of *parma* whereas it is really quite a different species. There are in the M. C. Z. collection specimens of *parma* from off the eastern United States which are a trifle higher than the lowest *obesa* from Kamtchatka and are not otherwise certainly distinguishable, so that *obesa* is clearly not a valid species or even a subspecies, but may conveniently be recognized as a variety. The pedicellariae are not distinguishable from those of typical *parma*. The bidentate have valves (Pl. 125, fig. *8*) .30–.40 mm. long, entirely lacking apophyses and with the tip somewhat serrate, under high power. The biphyllous (Pl. 125, fig. *7*) have valves only about .04 mm. long, and somewhat hood-shaped. No ophicephalous pedicellariae were found.

The Albatross brought back *obesa* from the following points:—

Station 4283. Off Tuliumnit Point, Chignik Bay, Alaska. 30–41 fms. Bk. s., br. sp.

Station 4786. Off Copper Island, Komandorskis. 54 fms. Gn. s.

Station 4787. Off Copper Island, Komandorskis. 54–57 fms. Gn. s.

Station 4794. Off Staritschkof Island, Kamtchatka. 58–69 fms. S., p.

Station 4795. Off Staritschkof Island, Kamtchatka. 48–69 fms. Gn. s., p.

Station 4796. Off Staritschkof Island, Kamtchatka. 48 fms. S., p., sh.

Bathymetrical range, 30–69 fms.

Sixty-seven specimens.

Echinarachnius asiaticus.

Michelin, 1859. Rev. et Mag. Zool., **2**, no. 9, p. 3.

Plate 143, figs. *1–4*.

There is hardly room for questioning the distinctness of this species but it is possible that it is not entitled to Michelin's name. His description of the color fits fairly well, but not exactly and his specimen was not as high as might be. But on the whole, it seems much better to use Michelin's name than to introduce a new one, particularly as his specimen came from Kamtchatka. The abactinal primary spines are strikingly different from those of *parma;* they are not only much stouter but they are conspicuously swollen at the tip and their almost white color adds to their prominence. They are numerous and of nearly uniform length, giving the test a coarser, heavier, and less velvety covering than that of *parma*. The general violet cast in the coloration varies somewhat in different

specimens, the shade depending largely on how much the primary spines are tinged; where they are nearly white the general coloration is very light, almost lavendar, but where they are distinctly purplish, the general effect is of course much darker.

The only specimens of this species taken by the ALBATROSS were at

Station 3781. Off Cape Nalacheff, Kamtchatka. 39–42 fms. Gy. s., g. Five specimens.

Echinarachnius mirabilis.

Scaphechinus mirabilis A. Agassiz, 1863. Proc. Acad. Nat. Sci. Philadelphia, p. 359.
Echinarachnius mirabilis A. Agassiz, 1872. Rev. Ech. pt. 1, p. 107.
Echinarachnius pacificus Pfeffer, 1881. Verh. Naturw. Ver. Hamburg-Altona im 1880, p. 65.
Echinarachnius tenuis Yoshiwara, 1898. Ann. Zool. Jap., **2**, p. 61.

Plate 125, fig. *6*.

The deep violet color, added to the very characteristic branching of the actinal ambulacral furrows, serve to make this species very easy to recognize, yet both Pfeffer and Yoshiwara have described *mirabilis* under other names. In the case of Yoshiwara however, there is considerable excuse, for he had only young specimens and their very delicate, flat tests, almost white in color, are at first glance very different from those of *mirabilis*. Thanks to Dr. Goto, I have examined Yoshiwara's types and am thus able to state that they are the young of *mirabilis*.

The bidentate pedicellariae of this species are noticeably different from those of *parma*. The valves (Pl. 125, fig. *6*) have straighter sides and more coarsely dentate tips, while there is also a more or less developed apophysis — not one which can be of much functional importance but still more than is to be found in the valves of *parma*.

Although this is one of the characteristic echinoderms of Japan, it was not taken by the ALBATROSS on either of her visits.

Dendraster.

Agassiz and Desor, 1847. Ann. Sci. Nat., ser. 3, **7**, p. 135.
Type, *Scutella excentrica* Eschscholtz, 1831. Zool. Atlas, **4**, p. 19.

It is, of course, merely a matter of opinion whether the peculiarities of "*Scutella excentrica*" entitle it to generic separation from Scutella and Echinarachnius. In my judgment however they do and I have accordingly accepted

Agassiz's and Desor's genus. So far as spines and pedicellariae go, Dendraster is not to be distinguished from Echinarachnius, yet the primary spines have a characteristic form, the tip (Pl. 125, figs. *4*, *5*) being somewhat swollen and then abruptly flattened and pointed. Pedicellariae seem to be very scarce and small; the bidentate have rather more of an apophysis than those of *Echinarachnius parma* but less than those of *E. mirabilis*. The genus contains but one species.

Dendraster excentricus.

Scutella excentrica Eschscholtz, 1831. Zool. Atlas, **4**, p. 19.
Dendraster excentricus Agassiz and Desor, 1847. Ann. Sci. Nat., ser. 3, **7**, p. 135.

This sand-dollar, characteristic of the Pacific coast of North America from Lower California to Alaska, was collected by the ALBATROSS at the following points:—

Union Bay, Bayne Sound, British Columbia.

Station 2835. Off Lower California, 26° 42′ 30″ N., 113° 34′ 15″ W., 5.5 fms. Gn. m.

Twenty-six specimens.

Echinodiscus.

Leske, 1778. Add. ad Klein, p. 131.
Type, *Echinodiscus bisperforatus*, Leske, 1778. Add. ad Klein, p. 132.

This genus is notable as the only one among the Scutellidae which has retained ophicephalous pedicellariae; at least, it is the only genus in which I have found them. They have three valves, as in all other Echini where they are known, and show no special peculiarities; the blade (Pl. 125, fig. *12*) is well rounded and quite spiny. The tridentate pedicellariae show some differences which will be mentioned under the different species. Primary spines with swollen and asymmetrical tips. The disks of the pedicels contain calcareous rods, with rounded knobs on the convex side; as in Echinarachnius, these rods lie, two in each sucker, with their concave sides towards each other.

Key to the Species of Echinodiscus.

Posterior ambulacra each with a deep, narrow, marginal slit, the depth of which may equal or even exceed the length of the unpaired petal . . . . . *auritus.*
Posterior ambulacra each with a lunule distal to petal.
Antero-lateral petals little if any longer than posterior; length of test usually exceeds its width; lunules short . . . . . *tenuissimus.*

Antero-lateral petals distinctly longer than posterior; width of test exceeds its length.
Lunules longer than longest petal . . . . . *bisperforatus.*
Lunules shorter than shortest petal . . . . . *bisperforatus* var. *truncatus.*

Echinodiscus auritus.

Leske, 1778. Add. ad Klein, p. 138.

Plate 125, figs. *9, 10.*

The biphyllous pedicellariae have broad valves (Pl. 125, fig. *9*) with rather flat blades, coarsely serrate on the margin. The bidentate are even more characteristic having the blade narrowed at base, while the basal part of the valve has the sides nearly parallel (Pl. 125, fig. *10*). The biphyllous valves are .07–.09 mm. long, the bidentate .10–.50 mm. No ophicephalous pedicellariae were seen.

The distribution of *auritus* seems to be chiefly in the western part of the Indian Ocean and in the Red Sea, but it is also known from several localities in the Dutch East Indies.

Echinodiscus tenuissimus.

Lobophora tenuissima Agassiz and Desor, 1847. Ann. Sci. Nat., ser. 3, **7**, p. 136.
Echinodiscus tenuissimus Gray, 1855. Cat. Rec. Ech., pt. 1, p. 20.
Echinodiscus laevis A. Agassiz, 1872. Rev. Ech., pt. 1, p. 113. (From Klein, 1734).

Plate 125, figs. *11, 12.*

All three kinds of pedicellariae occur. The ophicephalous have valves (Pl. 125, fig. *12*) only .10–.13 mm. long, exclusive of the loop which in the largest valve adds .07–.08 mm. more. The biphyllous valves are only .05–.06 mm. long. The bidentate valves (Pl. 125, fig. *11*) are .35–.40 mm. long; the blade is narrow with parallel sides while the basal part has sloping or oblique sides.

The distribution of *tenuissimus* is in the East Indian region from Japan southward to New Guinea.

Echinodiscus bisperforatus.

Leske, 1778. Add. ad Klein, p. 132.

Pedicellariae are very rare and only tridentate were found; their valves resemble those of *tenuissimus* (Pl. 125, fig. *11*). The distribution of this species seems to coincide with that of *auritus.*

Echinodiscus bisperforatus var. truncatus.

Lobophora truncata Agassiz, 1841. Mon. Scut., p. 66.

Although those who have examined the most specimens agree that this Echinodiscus is not a distinct species, the specimens I have seen are so very sharply separated from any other member of the genus, it seems to me desirable that they should at least bear a varietal name. Possibly this is the form Lamarck called *Scutella bifora* and in that case, his name might be used, but a variety "*bifora*" of a species "*bisperforatus*" seems absurd.

Astriclypeus.

Verrill, 1867. Trans. Conn. Acad., **1**, p. 311.

Type, *Astriclypeus manni* Verrill, 1867. *Loc. cit.*

This genus is characteristic of Japan and is not known from elsewhere. Tridentate and triphyllous pedicellariae, but no ophicephalous, were found. The spines are solid and only slightly swollen at the tip. The pedicels seem to lack calcareous particles of any kind.

Astriclypeus manni.

Verrill, 1867. Trans. Conn. Acad., **1**, p. 311.

Plate 125, figs. *13–15*.

The valves of the triphyllous pedicellariae (Pl. 125, fig. *15*) are quite flat with broadly rounded blades, with smooth margins. The tridentate valves vary much in size, ranging from .16 to .43 of a millimeter in length; the tips are coarsely dentate (Pl. 125, fig. *14*) and in small ones, there is often a single conspicuous tooth (Pl. 125, fig. *13*) at the tip. It is rather odd that the ALBATROSS failed to collect this species on either of her Japanese expeditions.

Encope.

Agassiz, 1841. Mon. Scut., p. 45.

Type, *Echinodiscus emarginatus* Leske, 1778. Add. ad Klein, p. 136.

Although in his great monograph of the scutellids, Agassiz recognized nearly a dozen species of Encope, and although several more were described in the succeeding thirty years, in the Revision Mr. Agassiz reduced them all to five valid species. The genus is exclusively American and the large amount of

material Mr. Agassiz has accumulated in the M. C. Z. collection from both sides of tropical America, shows well the variability in form of both test and lunules which characterizes some of the species. Nevertheless other species, particularly *grandis*, show very little diversity and we ought to recognize six species, since one of the forms, named *perspectiva* by Agassiz in 1841, and considered in the Revision as a form of *micropora*, seems quite distinct. The solidity of the test, the position of its apex, the position of the lunules, and the length of the petals furnish the best characters for separating the species. The size of the lunules may also be of use but in some cases, especially in *emarginata*, it is most unreliable.

The spines show no noteworthy peculiarities. The pedicellariae are all bivalved and small. It is difficult to draw any line between bidentate and biphyllous forms, for the two extremes intergrade so completely. The form of the blade differs somewhat in the different species, as will be noted below, but it is doubtful if these differences are perfectly constant. The disks of the tube-feet have rods in them much as in Echinarachnius.

Key to the Species of Encope.

Test moderately heavy with margins rarely exceeding 3 mm. in thickness, and usually much less.
- Test as high anterior to abactinal system as it is posteriorly and often distinctly higher.
  - Test elevated equally both anterior and posterior to abactinal system; interambulacral lunule large, variable in form, its length, .16–.35 test-length . *emarginata.*
  - Test distinctly highest anteriorly; interambulacral lunule variable in form, small, its length only .10–.17 test-length.
    - Anterior end of interambulacral lunule nearer distal end of posterior petals than to center of abactinal system . . . . . *micropora.*
    - Anterior end of interambulacral lunule nearer to center of abactinal system than to distal end of posterior petals . . . . . *perspectiva.*
- Test highest back of abactinal system, at anterior end of interambulacral lunule.
  - Ambulacral marginal slits rarely, if ever, closed to form lunules, often reduced in the anterior ambulacra to mere notches or even entirely wanting there; petaloid area large; posterior petals about .33 test-length and unpaired petal nearly or quite as long . . . . . *michelini.*
  - Ambulacra with completely closed, rounded lunules; petaloid area moderate, none of the petals, much exceeding .25 test-length . . . . . *californica.*

Test very heavy, about as wide as long; margin about 5 mm. thick; interambulacral lunules big and round; marginal notches wide, not very deep, rarely, if ever, closed to form lunules; posterior petals .35–.40 test-length; unpaired petal about .66 posterior . *grandis.*

Encope emarginata.

Echinodiscus emarginata Leske, 1778. Add. ad Klein, p. 136.
Encope emarginata Agassiz, 1841. Mon. Scut., p. 47.

Plate 125, fig. *25*.

The bidentate pedicellariae of this species are quite characteristic; the valves have several terminal teeth at tip of blade (Pl. 125, fig. *25*) and the blade itself is rather short. The range of *emarginata* is from Uruguay northward, certainly to Venezuela and probably to Yucatan. It has also been reported from Martinique, Florida, and South Carolina but these records are open to considerable doubt. The diversity in the size and form of the lunules, particularly the posterior interambulacral, is really very extraordinary.

Encope micropora.

Agassiz, 1841. Mon. Scut., p. 50.

There is no doubt that *Encope stokesii* Agass. (= *Mellita stokesii* of the Revision) is the young of this species, whose range is from Lower California to Peru and the Galapagos. The bidentate pedicellariae have valves provided with a relatively long terminal tooth which is flanked on either side by two or three teeth not much shorter. The Albatross collection contains specimens of *micropora* from two places.

James Island, Galapagos.

Station 2835. Off Lower California, 26° 42′ 30″ N., 113° 34′ 15″ W. 5.5 fms. Gn. m.

Five specimens.

Encope perspectiva.

Agassiz, 1841. Mon. Scut., p. 51.

The pedicellariae of this species are indistinguishable from those of *micropora*. Its geographical range is more northerly, from Lower California southward only to Costa Rica. There is little doubt that *Encope pacifica* Pfeffer, 1881, is identical with *perspectiva*. The only specimen of this species in the Albatross collection is from Ballenas Bay, Lower California. It is a bare test and shows a curious departure from normal in that the right posterior petal terminates abruptly, *proximally*, 8 mm. from the madreporite. Its distal termination is 28 mm. from the madreporite, so this fragment of a petal is only 20 mm. long.

Accompanying this change in the ambulacra, the genital pores of interambulacra five and one have shifted their position and lie side by side, 2 mm. apart and 3 mm. from the madreporite in the region which is normally occupied by the petal. The explanation of the whole appearance is, no doubt, that for some unknown reason, ambulacrum I ceased to grow when the petal was 20 mm. long and the region which it should have filled has been built up by the adjoining interambulacra, the unusual growth of which has caused the displacement of the genital pores. It is important to note that ocular I is in position, fused to the madreporite as usual. This case falls into group 15 of Jackson's twenty combinations of character in variations from pentamerous symmetry, and agrees almost exactly with some of the cases found in regular Echini, which he studied (Jackson, 1912, Mem. Boston Soc. Nat. Hist., **7**, p. 43).

Encope michelini.

Agassiz, 1841. Mon. Scut., p. 58.

The pedicellariae of this species agree with those of *emarginata*. Its geographical range is much more limited, for it seems to be confined to the shores of the Gulf of Mexico from Cape Florida and the Florida Keys around to Yucatan.

Encope californica.

Verrill, 1871. Trans. Conn. Acad., **1**, p. 586.

The bidentate pedicellariae of this species are like those of *grandis*, the tip of the blade of each valve forming a long terminal tooth. Like *grandis* too in its distribution, *californica* seems to be confined to the Gulf of California. The Albatross collection contains two specimens, one a long-dead worm-tube covered test, from

Station 2828. Gulf of California, 24° 11′ 30″ N., 109° 55′ W. 10 fms. Sh.

Encope grandis.

Agassiz, 1841. Mon. Scut., p. 57.

Plate 125, fig. *24*.

The bidentate pedicellariae have valves terminating in a conspicuous tooth (Pl. 125, fig. *24*), the margins being somewhat serrate. No other species of the genus is as easily recognized as this and no other shows so little variability. It seems to be also the least common member of the genus and appears to be confined to the Gulf of California.

Mellita.

Agassiz, 1841. Mon. Scut., p. 34.

Type, *Scutella quinquefora* Lamarck, 1816. Anim. sans Vert., **3**, p. 9 = *Echinodiscus quinquesperforatus* Leske, 1778. Add. ad Klein, p. 133.

Like the preceding this is strictly an American genus but whereas two thirds of the species of Encope occur on the *west* coast of tropical America, two of the four species of Mellita occur on the *east* coast. These clypeastroids give every indication of high specialization, not only in the extreme flatness of the test with the accompanying peculiarities of lantern and auricles, but in the lunules, the position of the periproct and even in the spines and pedicellariae. The spines are solid and the primaries are more or less swollen at the tip (Pl. 125, figs. *17*, *18*); they may be somewhat curved, while many of the miliaries are abruptly bent (Pl. 125, fig. *16*). The pedicellariae are greatly reduced in size and number and no ophicephalous are to be found. All have but two valves and these are of peculiar shape. Calcareous particles in the pedicels seem to be nearly or quite wanting; sometimes a few small rods may be present. The lunules afford the best characters for separating the species, both the number and the size and form being of real importance. There are four species which seem to be valid.

Key to the Species of Mellita.

Lunules 5.

Interambulacral lunule very variable in length but usually less than .20 test-length, and seldom much longer than posterior ambulacral lunules; if unusually long its breadth will be .15–.20 of its length . . . . . *quinquiesperforata.*

Interambulacral lunule long and very narrow, from .25 to .40 test-length and 40–100% longer than posterior ambulacral lunules; its breadth is less than .10 length . . . . . *longifissa.*

Lunules 6.

Interambulacral lunule long and narrow, its length at least twice and usually several times its own breadth . . . . . *sexiesperforata*

Interambulacral lunule broad and rounded, its length only about 25% more than its breadth . . . . . *pacifica.*

Mellita quinquiesperforata.

Echinodiscus quinquiesperforatus Leske, 1778. Add. ad. Klein, p. 133.

Mellita quinquiesperforata Meissner, 1904. Bronn's Thier-reichs, **2**, abt. 3, buch 4, p. 1384.

Plate 125, figs. *16–21.*

Pedicellariae are very scarce but the bidentate at least are quite characteristic. The valves are only .12–.18 mm. in length; they are somewhat compressed

and have a conspicuous hook or tooth, or usually two or three of them at the tip (Pl. 125, fig. *21*) but seen from within they are broad and the tip has several dentate projections; there is also a calcareous meshwork in the blade (Pl. 125, fig. *19*). The biphyllous are less distinctive; they have somewhat hood-shaped valves (Pl. 125, fig. *20*) about .07 mm. long.

This is the common "key-hole urchin" of the Florida coasts. The tests are found as far north as Nantucket and even in Vineyard Sound but the exact northern limit of the living animal is not known. It is common at Beaufort, N. C. and southward extends to Brazil.

Mellita longifissa.

Michelin, 1858. Rev. et Mag. Zool., **10**, p. 360.

Pedicellariae are very scarce but resemble those of *sexiesperforatus*. The geographical range of *longifissa* is from the Gulf of California to Panama.

Mellita sexiesperforata.

Echinodiscus sexiesperforatus Leske, 1778. Add. ad Klein, p. 135.
Mellita sexiesperforata Meissner, 1904. Bronn's Thier-reichs, **2**, abt. 3, buch 4, p. 1384.

Plate 125, figs. *22*, *23*.

The pedicellariae (Pl. 125, fig. *23*) of this species are recognizably distinct from those of *quinquiesperforata*, the most striking difference being that the valves of *quinquiesperforata* will lie flat on their backs while those of *sexiesperforata* are so compressed that they will not. The valves (Pl. 125, fig. *22*) are very small, only .10–.15 mm. long and the blade usually ends in a single sharp tooth.

This species occurs at the Bermudas and is known from Charleston, S. C. Southward it extends at least to Uruguay.

Mellita pacifica.

Verrill, 1867. Trans. Conn. Acad., **1**, p. 313.

Nothing is known of this species beyond the original description. I cannot avoid the feeling that it is an Encope and not a Mellita and is possibly identical with *E. micropora*. The type specimens were from Zorritos, Peru.

Rotula.

Agassiz, 1841. Mon. Scut., p. 23.

Type, *Rotula rumphii* Agassiz, *l. c.* = *Echinus orbiculus* Linné, 1758. Sys., Nat. ed. 10, p. 666.

Unfortunately I have been unable to examine any specimens of this genus except bare tests. One of these shows parts of the buccal membrane which seems to have been heavily plated, a most unusual condition in clypeastroids. The spines and pedicellariae will no doubt show some interesting peculiarities. The number of species in the genus is still uncertain, for while I can distinguish only the two which have long been known, Rochebrune (1881, Nouv. Arch. Mus. Paris, ser. 2, **4**, p. 328, pl. 19) figures two very different forms which he considers separate species, neither of which has lunules. Moreover none of the specimens examined have oval, nearly closed petals as in his figures, but always narrow, widely open petals with poriferous areas nearly parallel. Whether his figures err, or whether the form of the petals is very variable, or whether he is really dealing with species different from any I have seen, I am unable to decide.

Key to the Species of Rotula.

Test without lunules . . . . . *orbiculus.*
Test with a lunule in each anterior interambulacrum . . . . . *deciesdigitata.*

Rotula orbiculus.

Echinus orbiculus Linné, 1758. Sys. Nat., ed. 10, p. 666, no. 17*a*.
Rotula orbiculus Meissner, 1904. Bronn's Thier-reichs, **2**, abt. 3, buch 4, p. 1384.
Rotula rumphii Agassiz, 1841. Mon. Scut., p. 25. A. Agassiz, 1872. Rev. Ech., pt. 1, p. 155.

This species is known from Senegal and the Cape Verde Islands.

Rotula deciesdigitata, comb. nov.

Echinodiscus deciesdigitatus Leske, 1778. Add. ad Klein, p. 145.
Rotula augusti Agassiz, 1841. Mon. Scut., p. 28. A. Agassiz, 1872. Rev. Ech., pt. 1, p. 154.

This species is known only from Liberia and adjacent African coasts.

EXPLANATION OF THE PLATES.

Wherever the nature of the figure permits, the anterior ambulacrum (III) is placed uppermost.

PLATE 122.

PLATE 122.

1–4. **Clypeaster lamprus** H. L. Clark.

1. Large actinal primary spine; side view. × 6.
2. Actinal primary spine; side view. × 6.
3. Actinal primary spine; top view. × 2.
4. Tip of small primary spine; side view. × 60.

5–7. **Clypeaster rotundus** (A. Ag.).

5. Tip of primary spine; side view. × 70.
6. Tip of primary spine; top view. × 70.
7. Tip of miliary spine; side view. × 130.

8, 9. **Clypeaster leptostracon** A. Ag. & Cl.

8. Tip of miliary spine. × 150.
9. Tip of primary spine. × 70.

10. **Clypeaster audouini** Fourtau.

10. Tip of miliary spine. × 100.

11. **Clypeaster speciosus** Verrill.

11. Tip of primary spine. × 70.

12–14. **Clypeaster ravenelii** (A. Ag.).

12. Actinal ambulacral primary spine, from near mouth; side view. × 30.
13. Actinal ambulacral primary spine, from near mouth; top view. × 30.
14. Actinal interambulacral primary spine; side view. × 30.

15. **Clypeaster virescens** Död.

15. Terminal third of marginal primary spine; side view. × 70.

16–18. **Clypeaster pallidus** H. L. Clark.

16. Tip of actinal primary spine; side view. × 70.
17. Tip of abactinal primary spine; side view. × 70.
18. Tip of abactinal primary spine; top view. × 70.

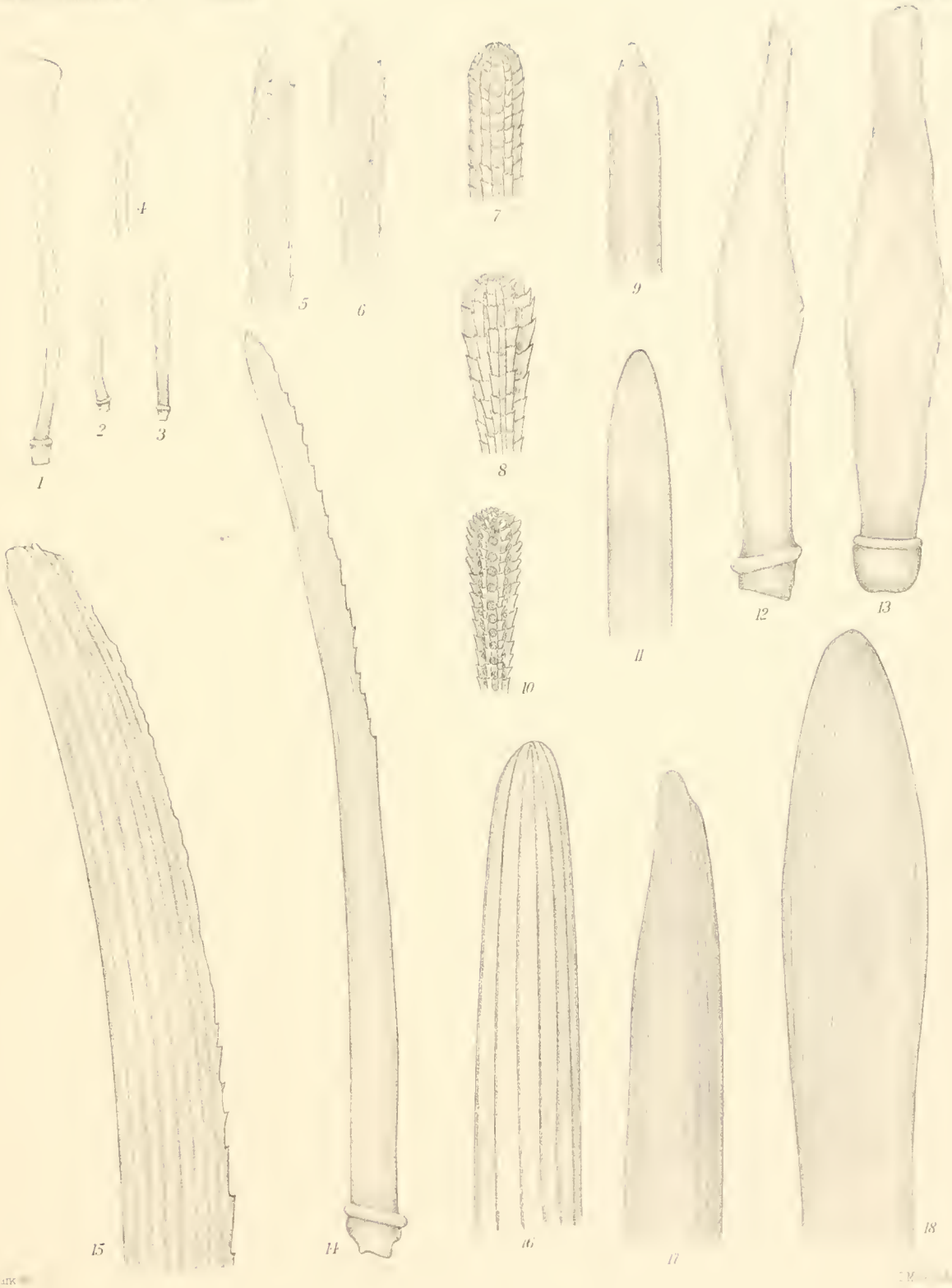
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PLATE 123.

1. **Clypeaster rosaceus** (L.).

1. Tridentate pedicellaria. × 30.

2–4. **Clypeaster pallidus** H. L. Clark.

2. Side view of valve of tridentate pedicellaria. × 30.
3. Blade of valve of tridentate pedicellaria. × 70.
4. Blade of valve of ophicephalous pedicellaria. × 70.

5–10. **Clypeaster ravenelii** (A. Ag.).

5. Side view of small valve of ophicephalous pedicellaria. × 70.
6. Side view of large valve of ophicephalous pedicellaria. × 70.
7. Interior view of valve of quadridentate pedicellaria. × 70.
8. Interior view of loop of valve of ophicephalous pedicellaria. × 70.
9. Interior view of loop of valve of ophicephalous pedicellaria. × 70.
10. Quadridentate pedicellaria. × 70.

11, 12. **Clypeaster subdepressus** (Gray).

11. Quadridentate pedicellaria. × 30.
12. Interior view of valve of quadridentate pedicellaria. × 30.

13–16. **Clypeaster europacificus** H. L. Clark.

13. Small valve of ophicephalous pedicellaria. × 70.
14. Large valve of ophicephalous pedicellaria. × 70.
15. Side view of valve of tridentate pedicellaria. × 70.
16. Valve of tridentate pedicellaria. × 70.

17–20. **Clypeaster leptostracon** A. Ag. & Cl.

17. Ophicephalous pedicellaria with valves open. × 70.
18. Triphyllous pedicellaria. × 70.
19. Valve of tridentate pedicellaria. × 70.
20. Small tridentate pedicellaria. × 70.

21, 22. **Clypeaster lamprus** H. L. Clark.

21. Small tridentate pedicellaria. × 70.
22. Valve of large tridentate pedicellaria. × 70.

23. **Clypeaster humilis** (Leske).

23. Interior view of loop of large valve of ophicephalous pedicellaria. × 70.

24. **Clypeaster audouini** Fourtau.

24. Valve of triphyllous pedicellaria. × 300.

25–27. **Clypeaster rotundus** (A. Ag.).

25. Valve of triphyllous pedicellaria. × 300.
26. Side view of valve of small tridentate pedicellaria. × 300.
27. Valve of tridentate pedicellaria. × 70.

28–31. **Clypeaster virescens** Död.

28. Blade of valve of ophicephalous pedicellaria. × 70.
29. Large tridentate pedicellaria. × 70.
30. Interior view of loop of valve of ophicephalous pedicellaria. × 70.
31. Interior view of loop of large valve of ophicephalous pedicellaria. × 70.


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PLATE **124.**

PLATE 124.

1, 2. **Clypeaster lytopetalus** A. Ag. & Cl.

1. Tridentate pedicellaria. × 70.
2. Valve of tridentate pedicellaria. × 70.

3–6. **Clypeaster reticulatus** (L.).

3. Valve of tridentate pedicellaria of specimen from Réunion. × 70.
4. Valve of tridentate pedicellaria of specimen from Mauritius. × 70.
5. Valve of tridentate pedicellaria of young specimen from Hawaii. × 70.
6. Valve of tridentate pedicellaria of adult specimen from Hawaii. × 70.

7–12. **Laganum depressum** Agass.

7. Valve of tridentate pedicellaria. × 70.
8. Side view of valve of tridentate pedicellaria. × 70.
9. Blade of valve of ophicephalous pedicellaria. × 350.
10. Exterior view of loop of valve *a* of ophicephalous pedicellaria. × 350.
11. Exterior view of loop of valve *b* of ophicephalous pedicellaria. × 350.
12. Exterior view of loop of valve *c* of ophicephalous pedicellaria. × 350.

13–16. **Laganum fudsiyama** Död.

13. Top of stalk of ophicephalous pedicellaria. × 350.
14. Rods of miliary spines. × 350.
15. Valve of small tridentate pedicellaria. × 70.
16. Valve of large tridentate pedicellaria. × 70.

17. **Laganum laganum** (Leske).

17. Valve of tridentate pedicellaria. × 70.

18–20. **Peronella rubra** Död.

18. Rods of a miliary spine. × 350.
19. Rod of another miliary spine. × 350.
20. Valve of a triphyllous pedicellaria. × 350.

21, 22. **Peronella peronii** (Agass.).

21. Blade of valve of ophicephalous pedicellaria. × 350.
22. Valve of triphyllous pedicellaria. × 350.

23, 24. **Peronella lesueuri** (Agass.).

23. Valve of triphyllous pedicellaria. × 350.
24. Valve of tridentate pedicellaria. × 350.

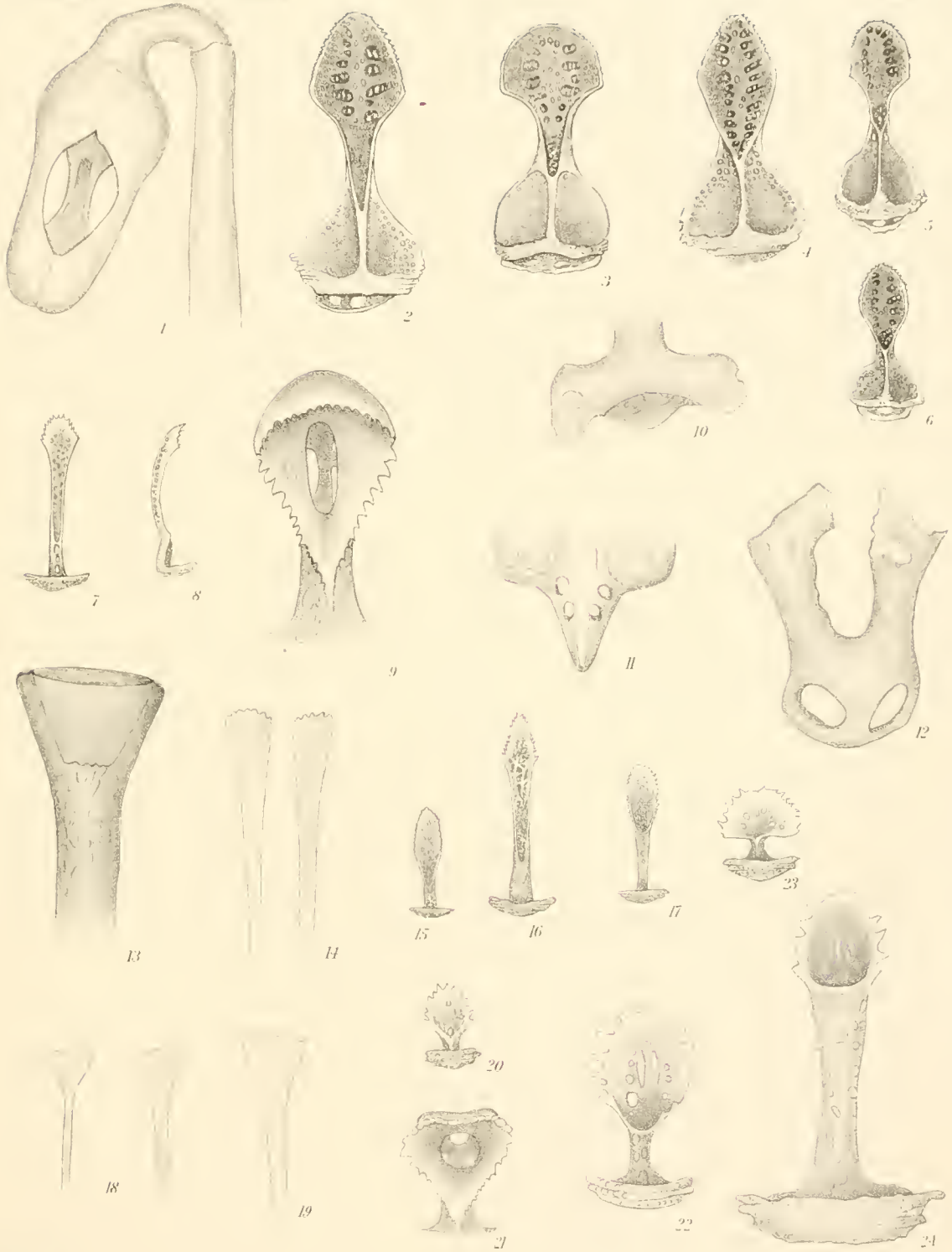
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PLATE 125.

Plate 125.

1–3. **Arachnoides placenta** (L.)

1. Bidentate pedicellaria, showing back of valve. × 70.
2. Bidentate pedicellaria, showing both valves. × 70.
3. Side view of tip of valve of bidentate pedicellaria. × 350.

4, 5. **Dendraster excentricus** (Esch.).

4. Side view of tip of primary spine. × 70.
5. Top view of tip of primary spine. × 70.

6. **Echinarachnius mirabilis** (A. Ag.).

6. Valve of bidentate pedicellaria. × 350.

7, 8. **Echinarachnius parma** (Lamarck).

7. Biphyllous pedicellaria. × 350.
8. Valve of bidentate pedicellaria. × 70.

9, 10. **Echinodiscus auritus** Leske.

9. Valve of biphyllous pedicellaria. × 350.
10. Valve of bidentate pedicellaria. × 70.

11, 12. **Echinodiscus tenuissimus** (Agass. & Des.).

11. Valve of bidentate pedicellaria. × 70.
12. Blade of valve of ophicephalous pedicellaria. × 350.

13–15. **Astriclypeus manni** Verrill.

13. Blade of valve of tridentate pedicellaria. × 350.
14. Tip of blade of valve of tridentate pedicellaria. × 350.
15. Valve of triphyllous pedicellaria. × 350.

16–21. **Mellita quinquiesperforata** (Leske).

16. Side view of miliary spine. × 350.
17. Top view of tip of primary spine. × 70.
18. Side view of tip of primary spine. × 70.
19. Valve of bidentate pedicellaria. × 350.
20. Side view of valve of biphyllous pedicellaria. × 350.
21. Side view of valve of bidentate pedicellaria. × 350.

22, 23. **Mellita sexiesperforata** (Leske).

22. Blade of valve of bidentate pedicellaria. × 350.
23. Bidentate pedicellaria. × 350.

24. **Encope grandis** Agass.

24. Side view of tip of valve of bidentate pedicellaria. × 350.

25. **Encope emarginata** (Leske).

25. Side view of tip of valve of bidentate pedicellaria. × 350.

PLATE **126.**

PLATE 126.

1–4. **Fibularia acuta** Yosh. × 6.

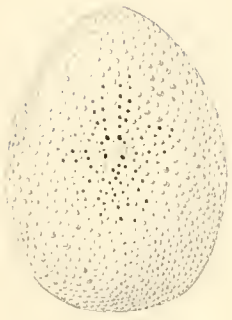
1. Abactinal surface of bare test of specimen from Asamiwan, Tsu-shima, Japan.
2. Actinal surface of same.
3. Interior view of actinal half of same.
4. Right-side view of same.

5–8. **Echinocyamus megapetalus** H. L. Clark. × 6.

5. Abactinal surface of bare test of specimen (holotype) from Mauritius.
6. Actinal surface of same.
7. Interior view of actinal half of same.
8. Right-side view of same.

9–11. **Echinocyamus elongatus** H. L. Clark. × 6.

9. Abactinal surface of bare test of specimen (holotype) from Hawaii, St. 3846.
10. Actinal surface of same.
11. Right-side view of same.



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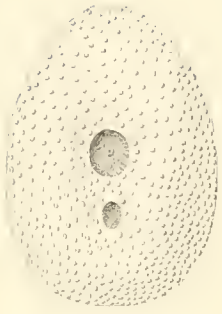

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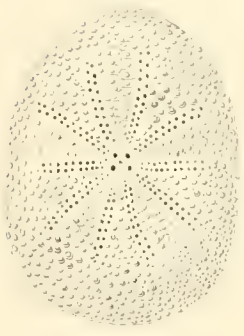

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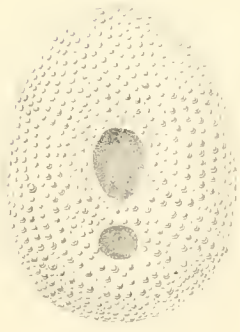

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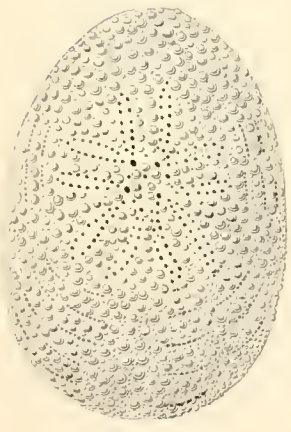

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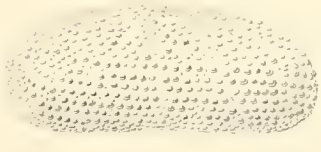

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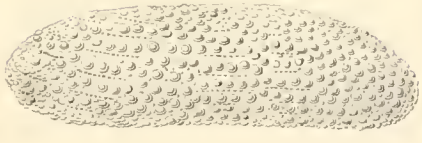

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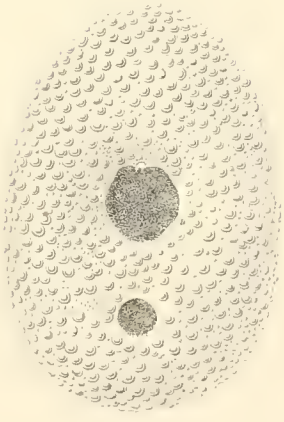

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PLATE **127.**

PLATE 127.

1–6. **Echinocyamus platytatus** H. L. Clark.

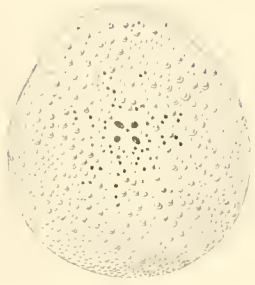
1. Abactinal surface of bare test of specimen (holotype) from Portsea, Victoria. × 6.
2. Actinal surface of same. × 6.
3. Interior view of actinal half of same. × 6.
4. Right-side view of same. × 6.
5. Abactinal system of male, showing small genital pores. × 12.
6. Abactinal system of female, showing large genital pores. × 12.

7, 8. **Laganum fudsiyama** Död.

7. Right anterior petal, showing coarse tubereulation. × 5.
8. Abactinal system. × 6.

9–12. **Laganum diploporum** A. Ag. & Cl.

9. Right anterior petal, showing fine tubereulation. × 5.
10. Abactinal system, showing double genital pore in posterior interambulacrum. × 10.
11. Abactinal system, showing two distinct genital pores in posterior interambulacrum. × 10.
12. Abactinal system, showing two well-separated genital pores in posterior interambulacrum. × 10.



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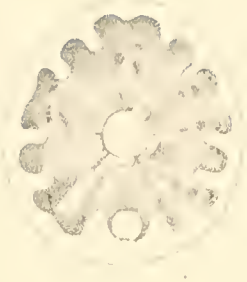

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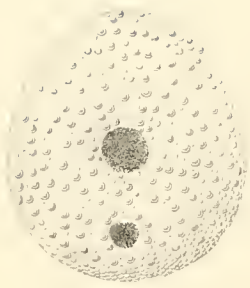

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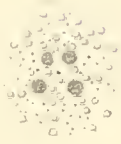

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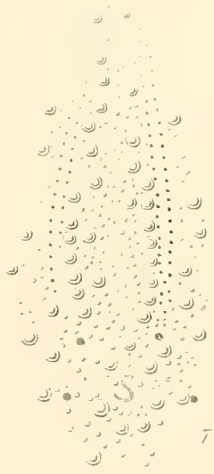

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PLATE 128.

PLATE 128.

1–3. **Echinocyamus incertus** H. L. Clark. × 6.

1. Abactinal surface of bare test of specimen (holotype) from Hawaii, St. 4045.
2. Actinal surface of same.
3. Right-side view of same.

4. **Clypeaster australasiae** (Gray).

4. Part of right poriferous area of anterior petal. × 5.

5. **Clypeaster japonicus** Död.

5. Part of right poriferous area of anterior petal. × 5.

6. **Clypeaster rotundus** (A. Ag.).

6. Part of right poriferous area of anterior petal. × 5.

7. **Clypeaster speciosus** Verr.

7. Part of right poriferous area of anterior petal. × 5.

8. **Clypeaster virescens** Död.

8. Part of right poriferous area of anterior petal. × 5.

PLATE 129

PLATE 129.

Clypeaster europacificus H. L. Clark.

Abactinal view of partly denuded specimen (holotype) from the Gulf of Panama, 33 fms., St. 2795.

Natural size.

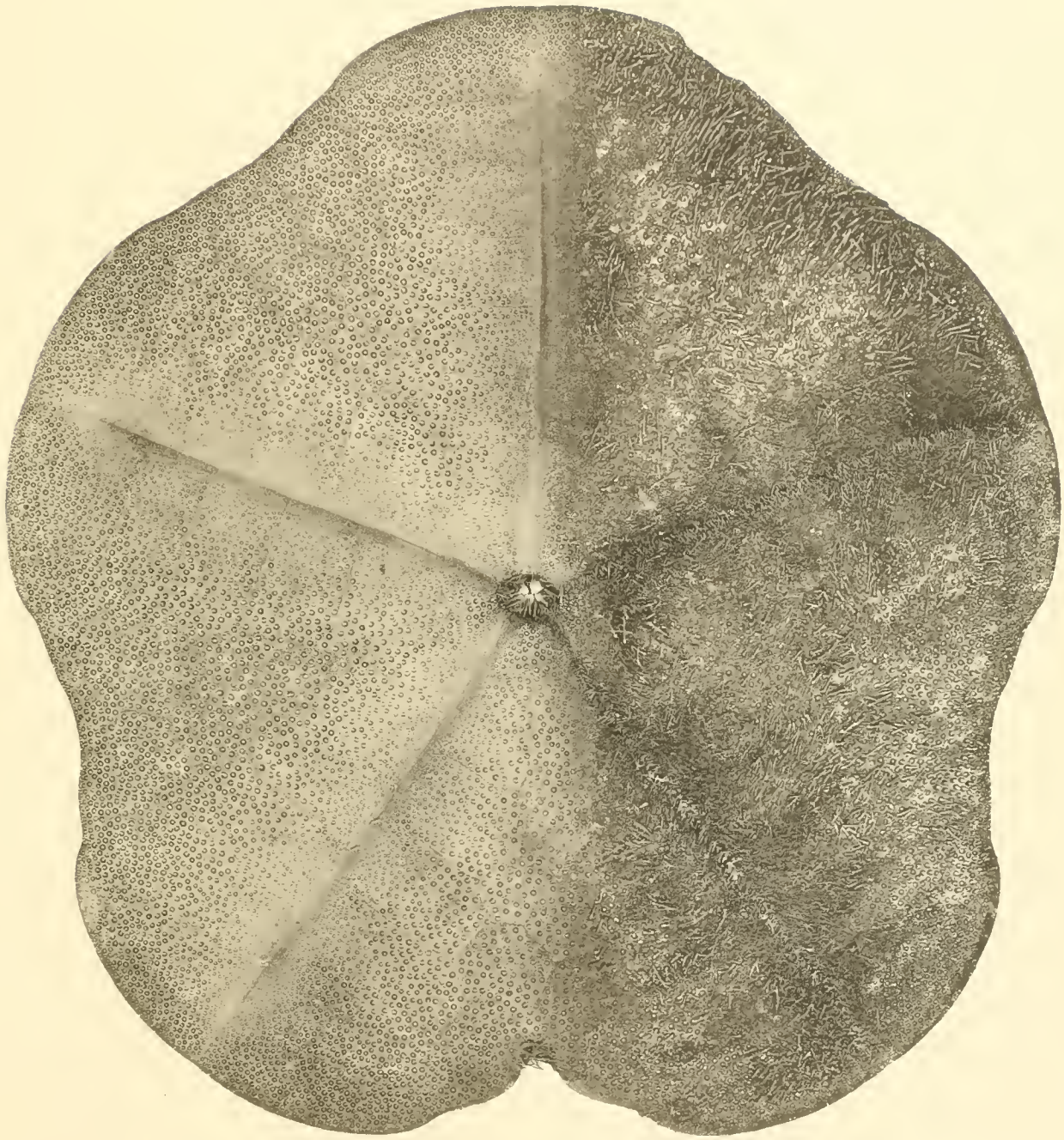
Heliotype Co. Boston.

PLATE 130.

PLATE 130.

Clypeaster europacificus H. L. Clark.

Actinal view of same specimen as that shown on Plate 129.
Natural size.



Heliotype Co Boston

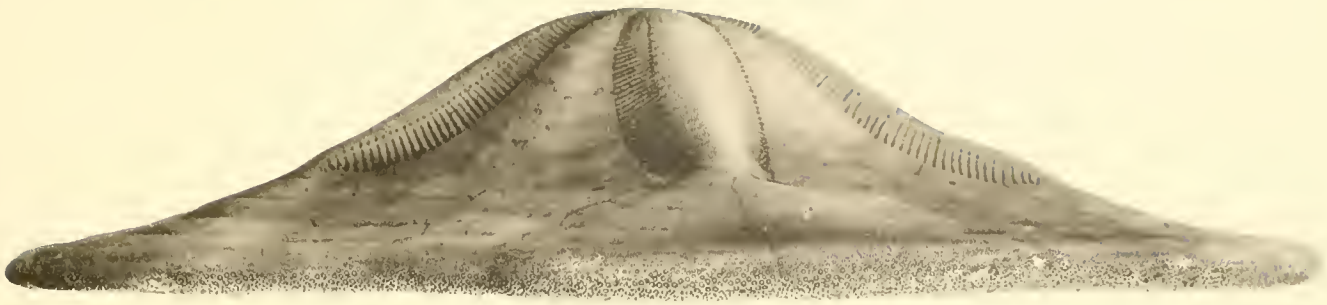
PLATE **131.**

PLATE 131.

Clypeaster europacificus H. L. Clark.

1. Abactinal view of denuded test of specimen from Gulf of California, St. 3014.
2. Right-side view of same specimen as that shown on Plates 129 and 130.

Natural size.



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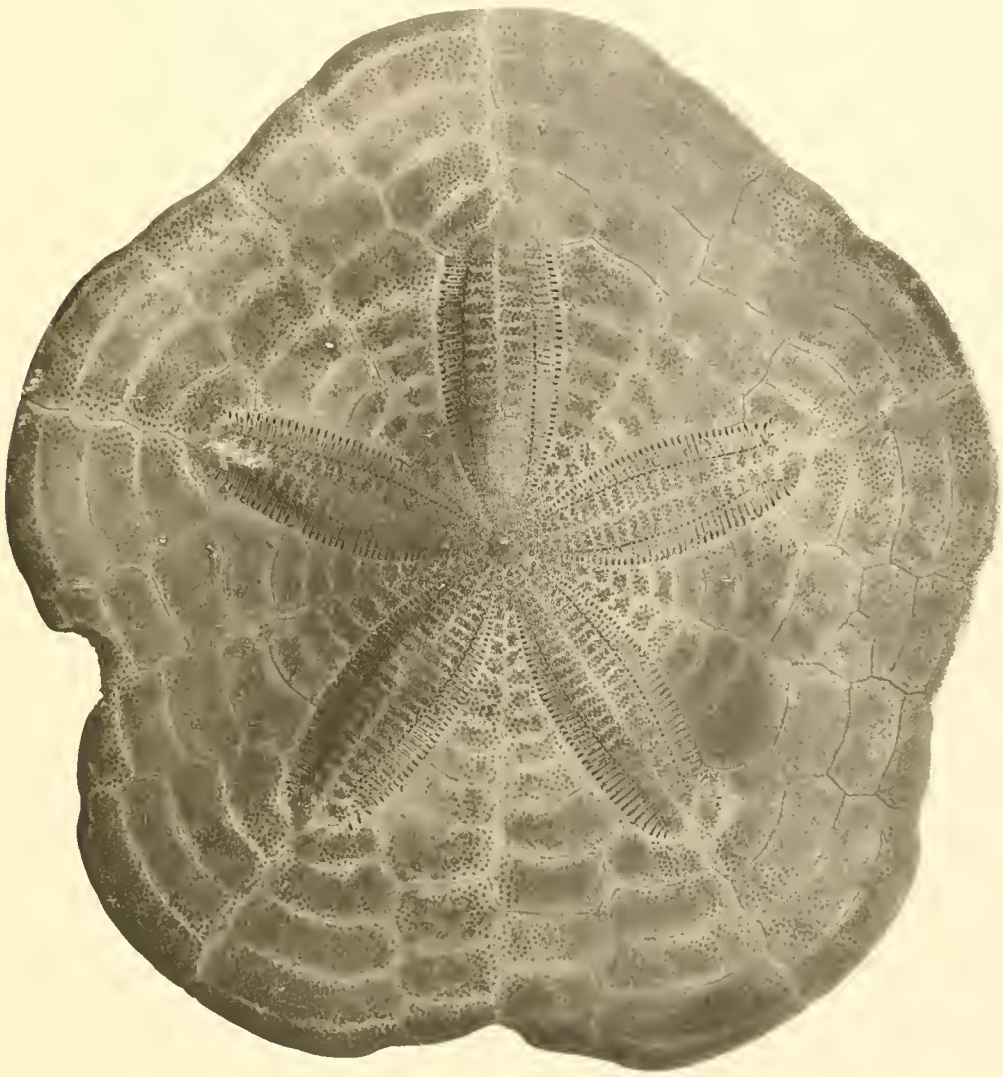

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Heliotype Co Boston

PLATE **132.**

PLATE 132.

Clypeaster rotundus (A. Ag.).

Abactinal view of partly denuded, large specimen from Gulf of Panama, St. 2796. Natural size.

Heliotype Co Boston

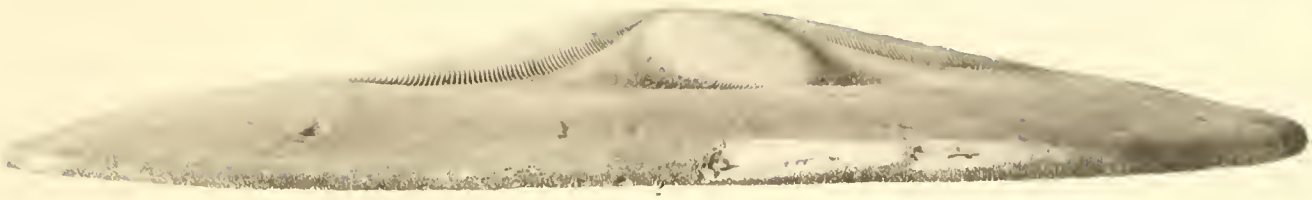
PLATE 133.

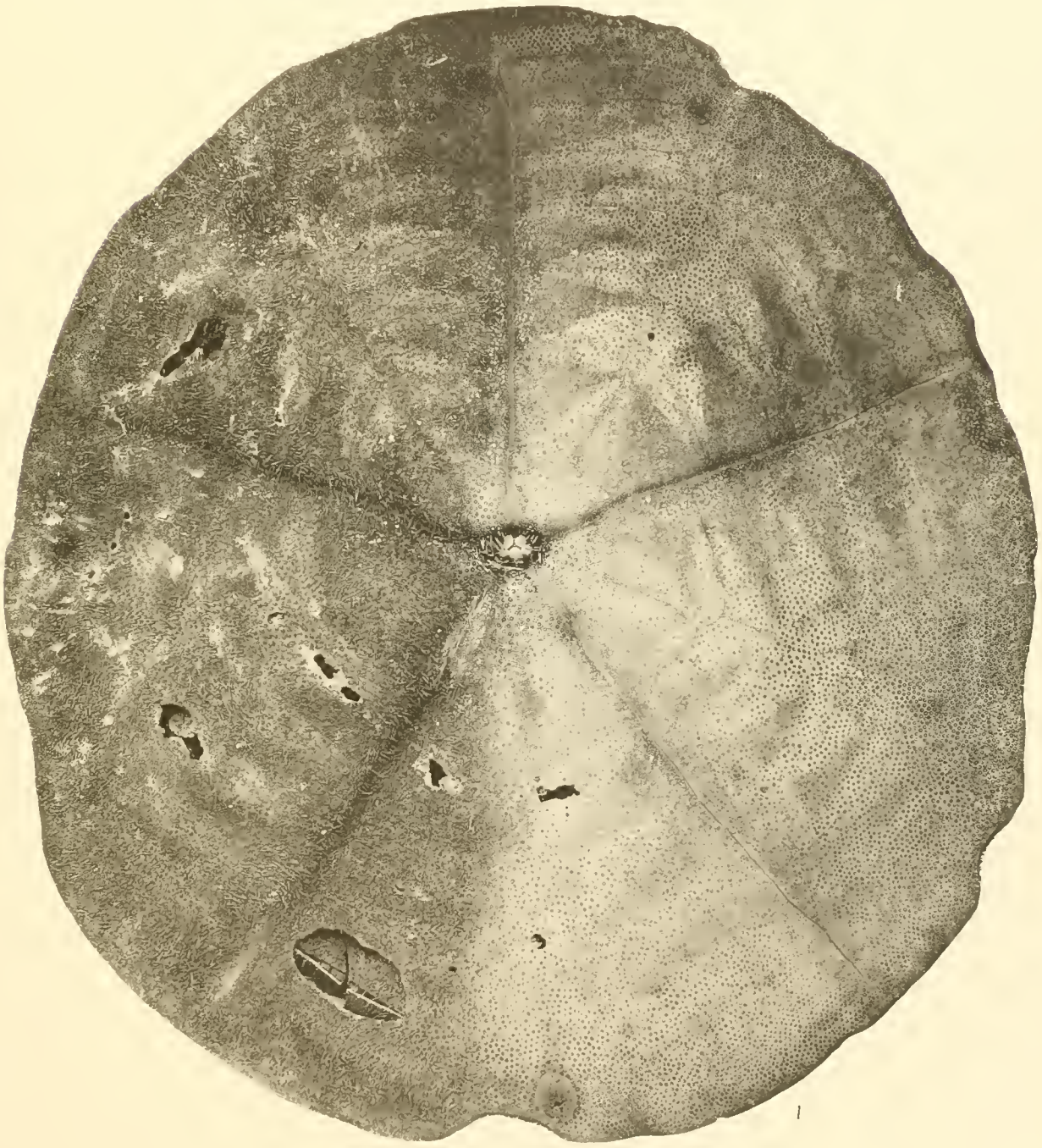
PLATE 133.

Clypeaster rotundus (A. Ag.).

1. Actinal view of same specimen as that shown on Plate 132.
2. Right-side view of same specimen.

Natural size.





Heliotype Co Boston.

PLATE **134.**

PLATE **134**.

1–3. **Clypeaster australasiae** (Gray).

1. Abactinal view of large adult specimen from Port Jackson, New South Wales.
2. Abactinal view of young specimen from Port Jackson, New South Wales.
3. Actinal view of same.

Natural size.

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Heliotype Co Boston

PLATE 135.

PLATE 135.

1, 2. **Clypeaster speciosus** Verrill.

1. Abactinal view of bare test of specimen from Magdalena Bay, Lower California.
2. Actinal view of same.

3–5. **Clypeaster leptostracon** A. Ag. & Cl.

3. Actinal view of partly denuded specimen (holotype) from Hawaii, St. 4046.
4. Right-side view of same.
5. Abactinal view of same.

6. **Clypeaster australasiae** (Gray).

6. Right-side view of same specimen as that shown in fig. 2, Pl. 134.

All figures, natural size.

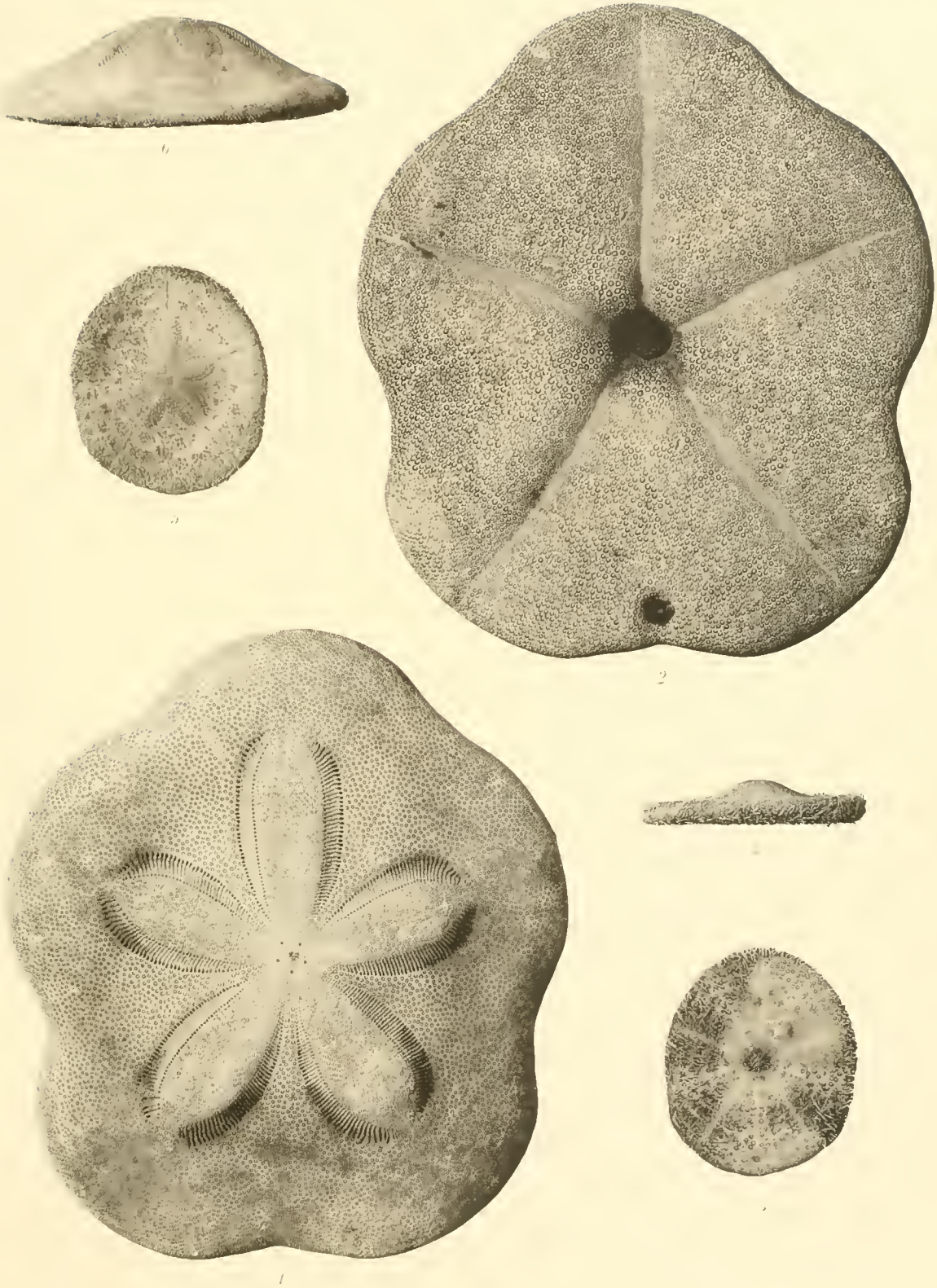


PLATE 136.

PLATE 136.

1. **Clypeaster europacificus** H. L. Clark.

1. Abactinal view of partly denuded young specimen from Gulf of Panama, St. 2795.

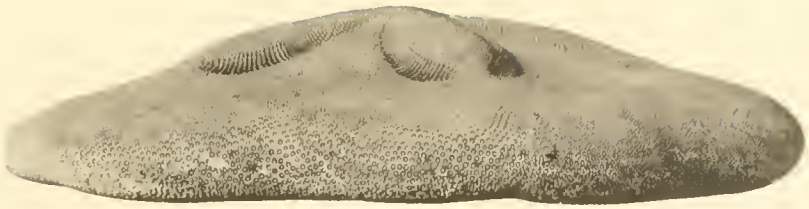
2–4. **Clypeaster japonicus** Död.

2. Right-side view of bare test of long specimen from Tokyo, Japan.
3. Abactinal view of same.
4. Actinal view of same.

5. **Clypeaster speciosus** Verrill.

5. Right-side view of bare test; same specimen as that shown in fig. 1, Plate 135.

All figures, natural size.



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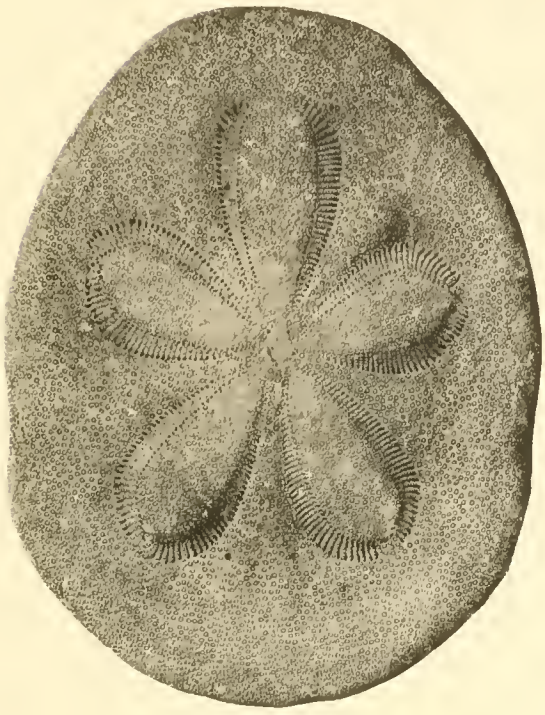

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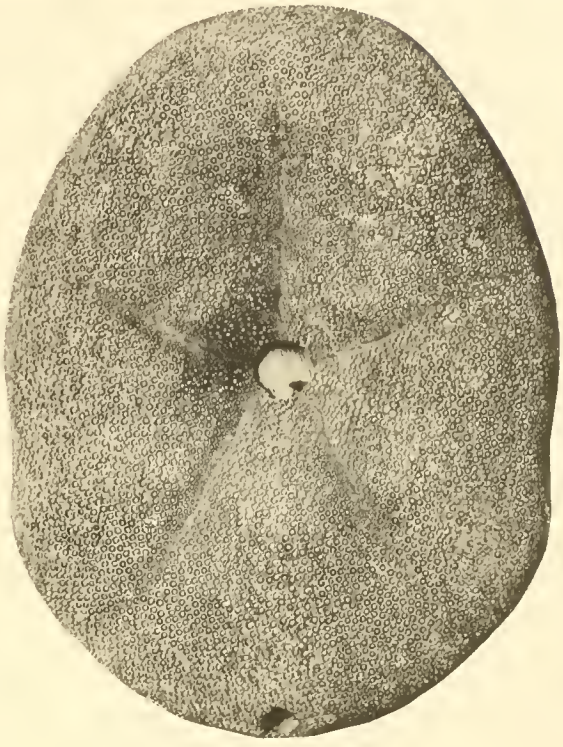

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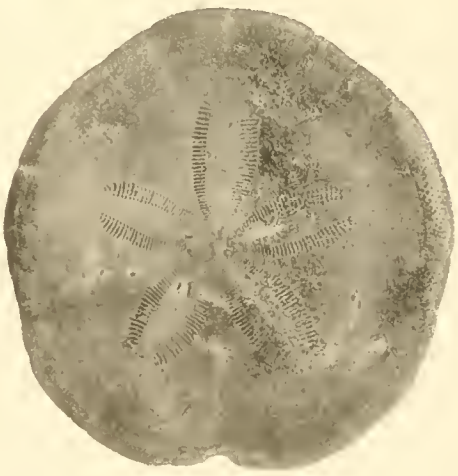

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Heliotype Co Boston

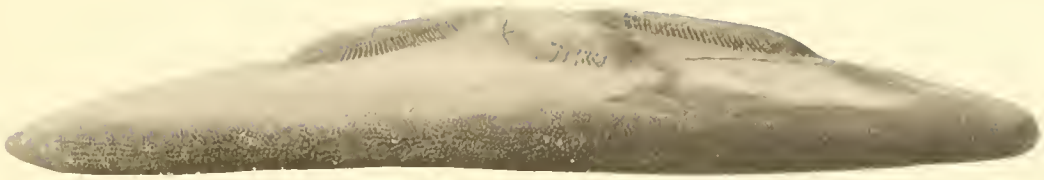
PLATE **137.**

PLATE 137.

Clypeaster humilis (Leske).

1. Abactinal view of bare test of specimen from unknown locality.
2. Right-side view of same.

Natural size.



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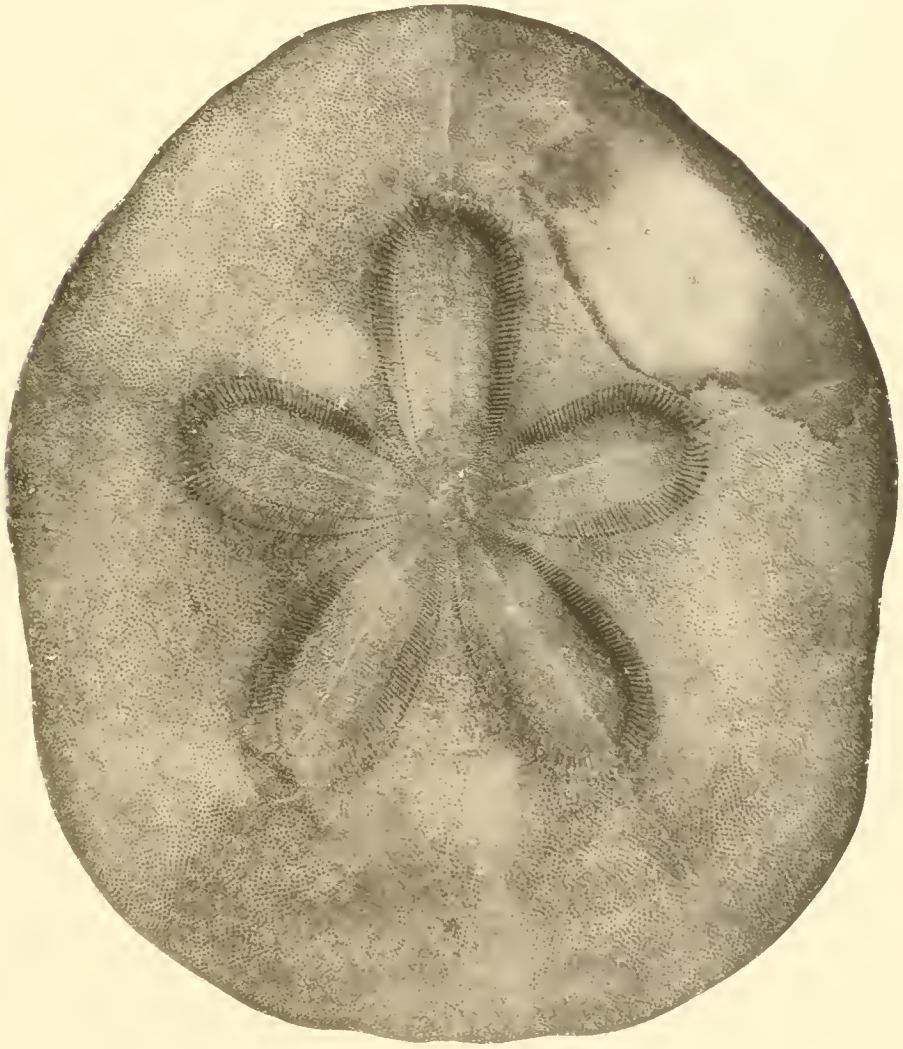

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PLATE 138.

PLATE 138.

1–3. **Clypeaster lytopetalus** A. Ag. & Cl.

1. Abactinal view of partly denuded test of specimen (holotype) from Hawaii, St. 3962.
2. Aetinal view of same.
3. Left-side view of same.

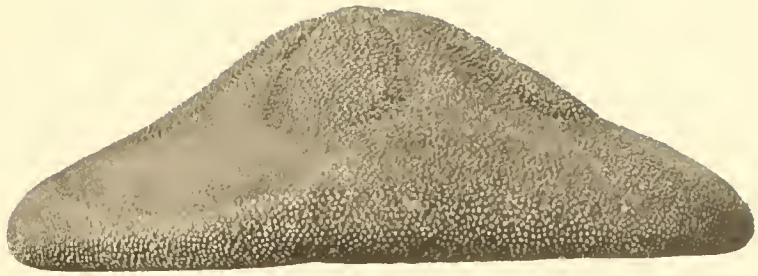
4. **Clypeaster humilis** (Leske).

4. Actinal view of same specimen as that shown in fig. 1, Pl. 137.

5. **Clypeaster japonicus** Död.

5. Left-side view of partly denuded test of unusually high specimen from Sagami Sea, Japan.

All figures, natural size.



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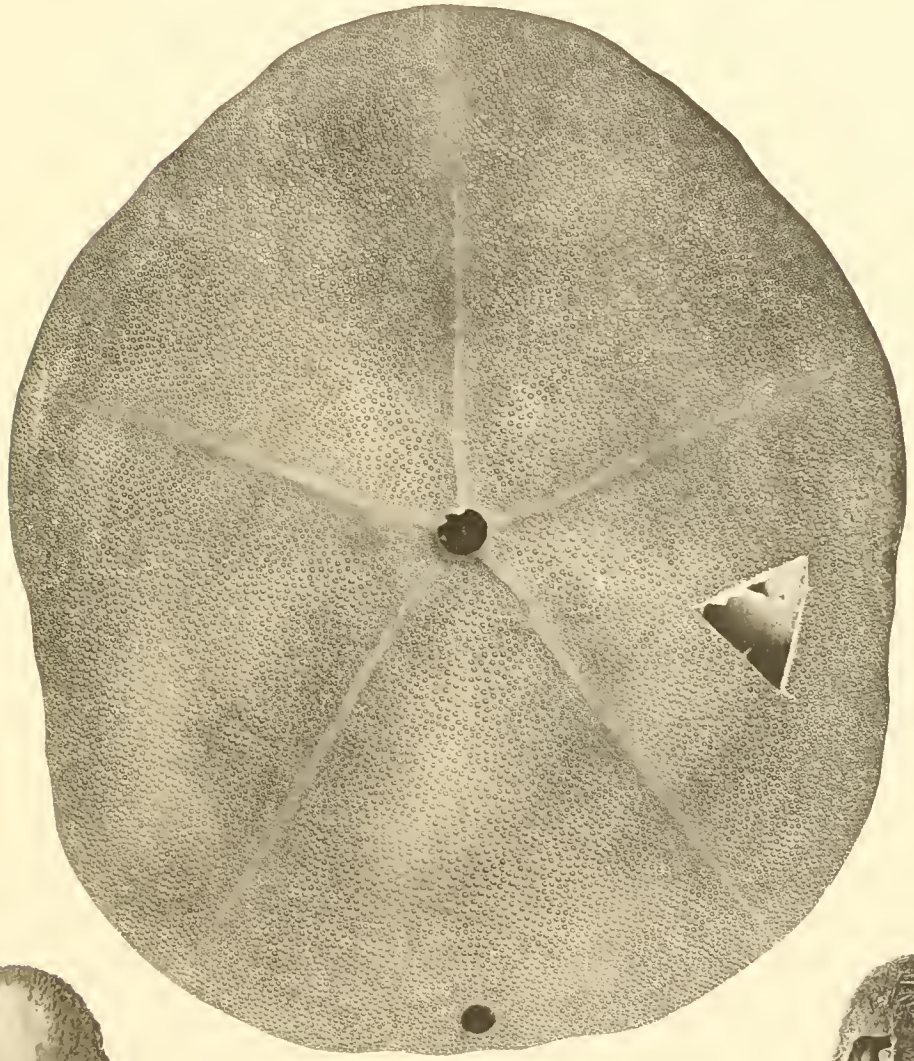

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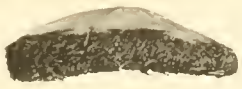

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PLATE **139.**

PLATE 139.

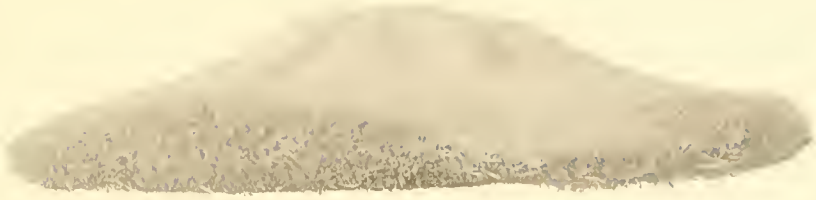
1–3. **Clypeaster pallidus** H. L. Clark.

1. Abactinal view of partly denuded specimen (holotype) from Barbados, 94 fms.
2. Actinal view of same.
3. Right-side view of same.

4. **Clypeaster virescens** Död.

4. Right-side view of partly denuded specimen from Japan, St. 5071.

All figures, natural size.



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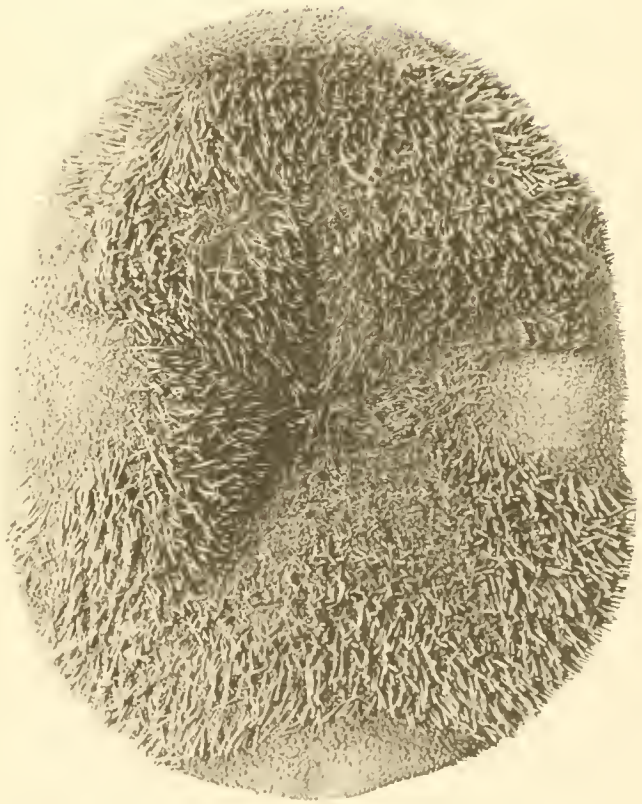

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PLATE 140.

PLATE 140.

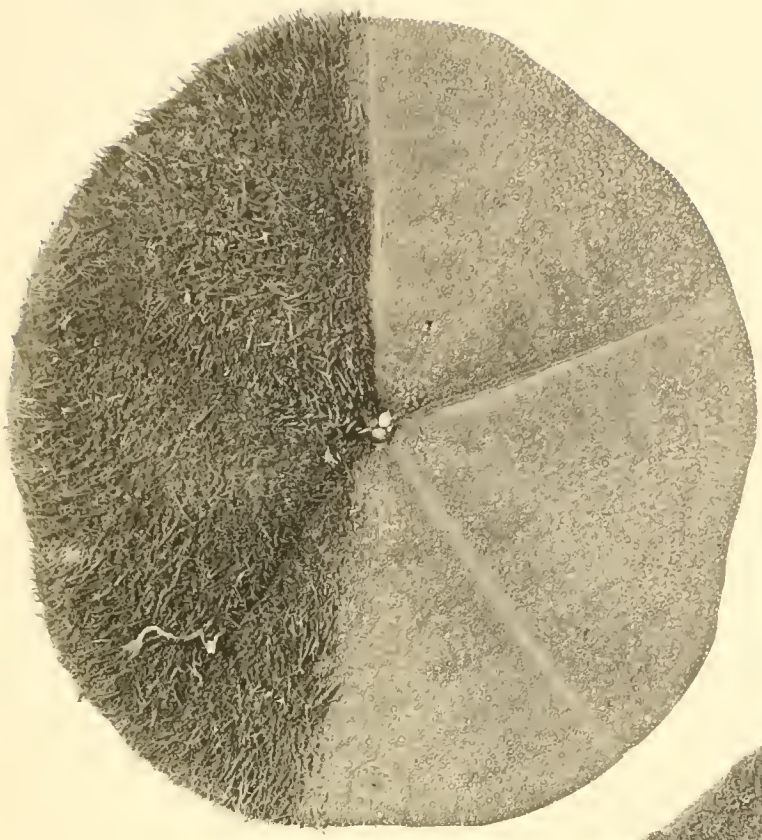
1, 2. **Clypeaster virescens** Död.

1. Abactinal view of partly denuded specimen; same as that shown in fig. 4, Plate 139.
2. Actinal view of same.

3, 4. **Laganum fudsiyama** Död.

3. Abactinal view of large specimen from Japan, St. 5091.
4. Abactinal view of denuded specimen from Japan, St. 4965.

All figures, natural size.



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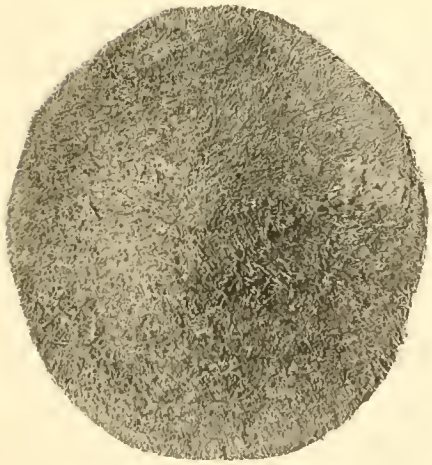

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Photocrypt Boston

PLATE 141.

PLATE 141.

1–3. **Clypeaster ochrus** H. L. Clark.

1. Abactinal view of partly denuded specimen (holotype) from Acapulco, Mexico.
2. Actinal view of same.
3. Right-side view of same.

4–9. **Laganum fudsiyama** Död.

4. Right-side view of same specimen as that shown in fig. 4, Pl. 140.
5. Actinal view of same.
6. Abactinal view of denuded specimen from Hawaii, St. 4081.
7. Right-side view of same.
8. Abactinal view of a partly denuded specimen from Hawaii, St. 4080.
9. Actinal view of same, showing color-pattern.

All specimens, natural size.

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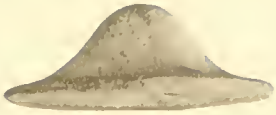

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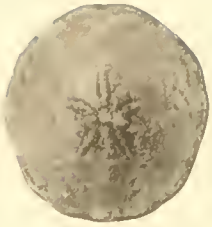

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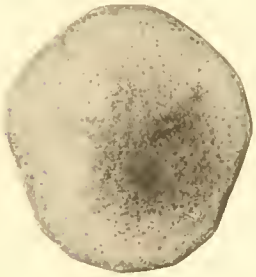

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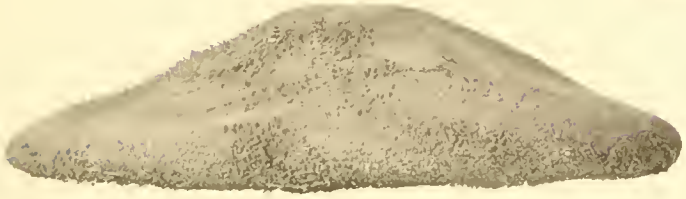

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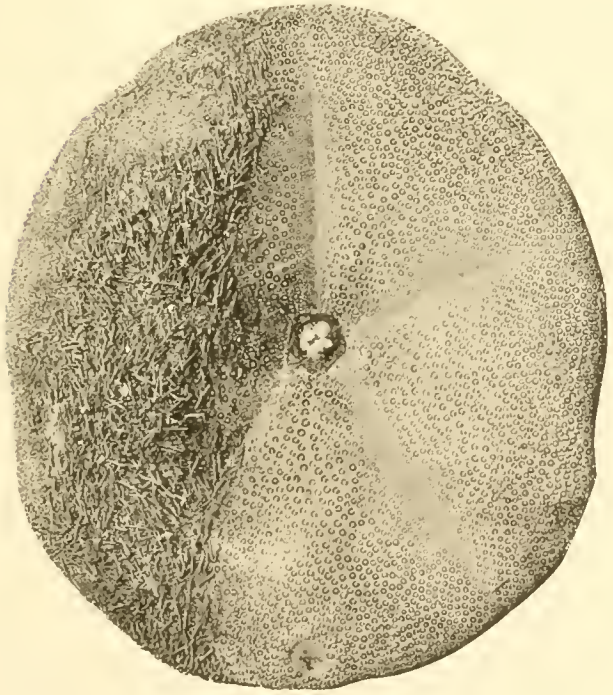

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PLATE **142.**

PLATE 142.

1, 8–10. **Peronella pellucida** Död.

1. Abactinal view of partly denuded adult specimen from Uraga Channel, Japan, 20 fms.
8. Actinal view of another specimen from Japan.
9. Right-side view of same.
10. Abactinal view of same.

2–4. **Laganum diploporum** A. Ag. & Cl.

2. Actinal view of partly denuded specimen (holotype) from Japan, St. 3707.
3. Abactinal view of same.
4. Right-side view of same.

5–7. **Peronella rubra** Död.

5. Abactinal view of partly denuded adult specimen from Uraga Channel, Japan, 20 fms.
6. Actinal view of same.
7. Right-side view of same.

11–13. **Peronella strigata** (A. Ag. & Cl.).

11. Abactinal view of specimen (holotype) from Hawaii, St. 3859.
12. Actinal view of same.
13. Right-side view of same.

14–16. **Laganum putnami** A. Ag.

14. Abactinal view of specimen from Ousima, Japan.
15. Actinal view of same.
16. Right-side view of same.

All figures, natural size.

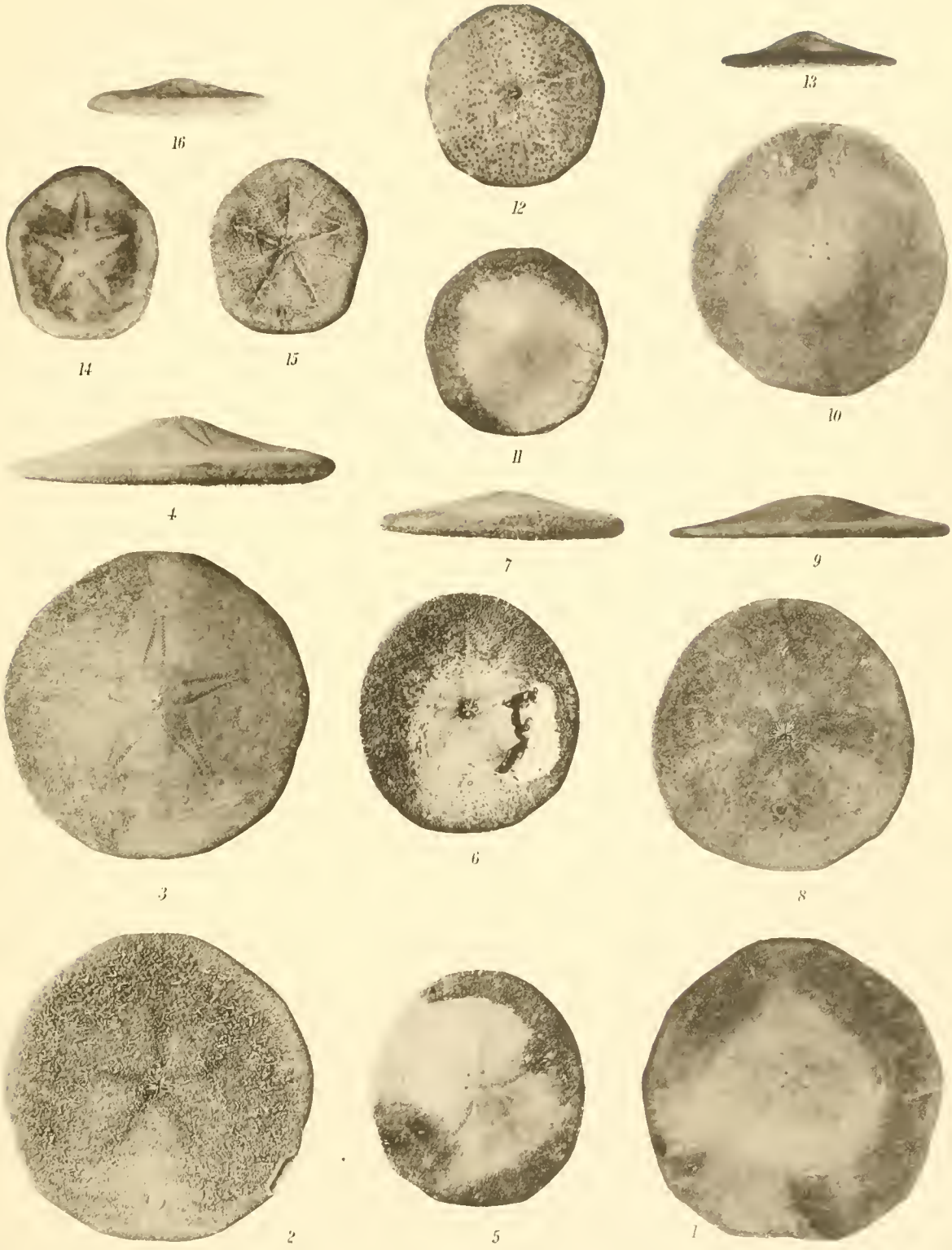

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PLATE **143.**

PLATE 143.

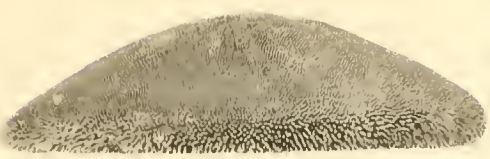
1–4. **Echinarachnius asiaticus** Mich.

1. Abactinal view of partly denuded specimen from Kamtchatka, St. 3781.
2. Right-side view of same.
3. Actinal view of same.
4. Right-side view of another specimen from same station.

5–8. **Echinarachnius parma** var. **obesa** H. L. Clark.

5. Abactinal view of partly denuded specimen from Kamtchatka.
6. Right-side view of same.
7. Actinal view of same.
8. Right-side view of specimen from Komandorski Islands, St. 4786.

All figures, natural size.



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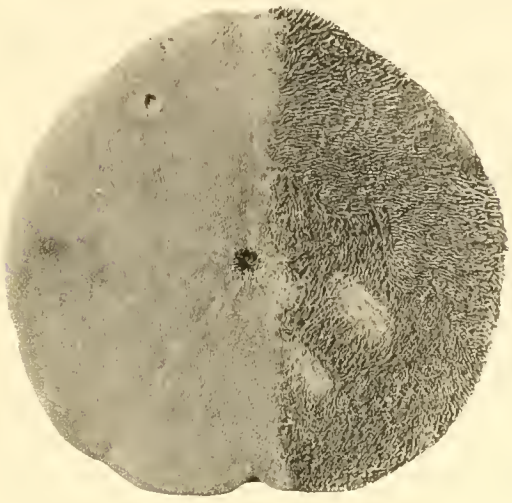

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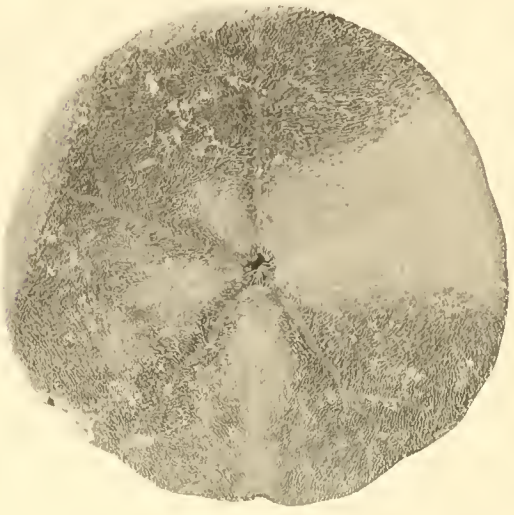

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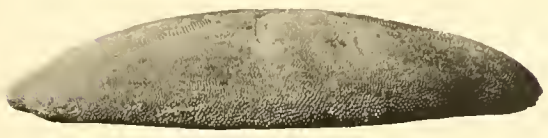

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